# City of Merritt
# Community Wildfire Protection Plan
# 2015 Update


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**Submitted To:**
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**City of Merritt, BC**

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# EXECUTIVE SUMMARY

| Communication and Education | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: To improve public understanding of fire risk and personal responsibility by increasing resident awareness of the wildfire threat in their community and to establish a sense of homeowner responsibility. | | | |
| 1 | High | • Develop a demonstration FireSmart property in a central location in the Regional District to provide homeowners with a working example of what a FireSmart home and property looks like and how it can be achieved. | $3,000 |
| 2 | High | • Upgrade the City and the Merritt Fire Rescue website to display or link wildfire prevention information and display real time information on fire bans and high fire danger, and provide a link to FireSmart information. | Within current operating costs |
| 3 | High | • Utilize social media (*e.g.*, Facebook, Twitter, etc.) to communicate fire bans, high fire danger days, wildfire prevention initiatives and other real time information. | Within current operating costs |
| 4 | High | • Deliver wildfire preparedness education in elementary and high schools. | Within current operating costs |
| 5 | Moderate | • Fire Departments should rate houses on suitability for triage and share rating information and recommendations with homeowners in high hazard areas. | Within current operating costs |
| 6 | Moderate | • Post information from the CWPP on the City website showing areas with hazardous fuel complexes. | Within current operating costs |
| 7 | Low | • Install educational signage in high fire ignition areas. | $5,000 + maintenance |
| 8 | Low | • Encourage more frequent visits by the Fire Department during high and extreme fire danger times to high ignition areas (e.g., homes, parks, trails, *etc*.). | Within current operating costs |
| **Objective:** To enhance the awareness of elected officials and stakeholders regarding the resources required to mitigate fire risk. | | | |
| 9 | Moderate | • Establish a regional interface committee to coordinate wildfire risk reduction efforts and aim to integrate forest licensees that are operating within the Merritt TSA. Coordination of fuel management activities with forest licensees could significantly aid in the establishment of large, landscape-level fuel breaks or compliment current or proposed fuel treatment areas. | Within current operating costs |

| Structure Protection and Planning | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: Enhance protection of critical infrastructure from wildfire. | | | |
| 10 | High | • Prioritize upgrades for critical infrastructure to ensure all buildings are to FireSmart standards. | Within current operating costs |
| 11 | High | • Complete a detailed review of back-up power source options for all critical infrastructure and upgrade as required. | Within current operating costs |
| **Objective:** Encourage private homeowners to voluntarily adopt FireSmart principles on their properties | | | |
| 12 | High | • Apply for funding under the 2016 SWPI FireSmart Grant Program to undertake FireSmart planning activities for private lands. | $10,000 (UBCM FireSmart Grant) |
| 13 | High | • Encourage residents to adopt FireSmart principles on their property through communication and education initiates including establishment of a FireSmart home and yard within the City boundary to provide homeowners with an example of what a FireSmart property looks like. | Within Current Operating Costs/One-time additional cost $3000 |

| Emergency Response | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: To improve structural and wildfire equipment and training available to City Fire and Rescue. | | | |
| 14 | High | • Complete the acquisition of the proposed pumper tanker for the City Fire Department. | Within current annual operating costs |
| 15 | High | • In partnership with the TNRD, assess the need for and fund the purchase of a water tender with an Underwriters Laboratory rated pumping capacity to support emergency response in Fire Protection Agreement areas which border the City. | $400,000 (one time cost) |
| 16 | High | • Support the acquisition of a Sprinkler Trailer resource and provide sprinkler deployment training for all department members. The kit should be able to protect up to 30 rural widely spaced interface homes. | $40,000 (one time cost) |
| 17 | High | • Maintain current structural and interface training with all Fire Departments and MFLNRO BCWS, and conduct annual reviews to ensure PPE and wildland equipment resources are complete. Interface training should include completion of a mock wildfire simulation in coordination with BCWS. | Within current annual operating costs |
| 18 | Moderate | • Provide S215 training to all/some members of the City Fire Department to enhance wildfire suppression training. | $2,000 (annually) |
| 19 | Moderate | • The City should consider developing an Evacuation Plan in coordination with the local RCMP detachment to: map and identify safe zones; marshalling points and aerial evacuation locations; plan traffic control and accident management; identify volunteers that can assist during and/or after evacuation; and create an education/communication strategy to deliver the information. | $7,000 + maintenance |
| 20 | Low | • Support on-call staff recruitment and training for the Lower Nicola Indian Band and Coldwater Indian Band. | Within current annual operating costs |
| **Objective:** To enhance communication and cooperation among fire departments. | | | |
| 21 | High | • Encourage homeowners to post house numbers in a manner that makes them clearly visible to aid emergency response. | Within current annual operating costs |
| 22 | Moderate | • Complete fire triage of homes in the WUI to improve the potential for structures to survive an event by educating homeowners of the improvements they can make. | Within current annual operating costs |

| Fuel Management |
|---|

| Item | Priority | Recommendation | Estimated Cost ($) |
|---|---|---|---|
| **Objective**: Reduce wildfire threat on private and public lands through fuel management. | | | |
| 23 | High | • The City should apply for funding to conduct maintenance for previously treated areas | UBCM SWPI Funding / Municipal Funding |
| 24 | High | • The City should identify potential partnerships to fund establishment of a 3 m fuel-free zone immediately adjacent to the north side of the Central Park Walking Trail. Alternatively, work with the City's Public Works department to implement this treatment by incorporating mitigation into the existing Public Works program | $5,000 |
| 25 | High | • Design, plan and implement a treatment to protect critical infrastructure on Iron Mountain. | $15,000 |
| 26 | Moderate | • Work with BCWS to implement prescribed fire at the airport as part of the training regime for new recruits and the Merritt Fire Zone training centre | Funding through existing programs |
| **Objective:** Establish landscape-level fuelbreaks to enhance community protection. | | | |
| 27 | High | • Seek funding to develop prescriptions for landscape level fuel breaks. The SWPI program currently does not fund these activities; however, expected changes to the program may allow funding in the future. | $10,000 |
| 28 | High | • In cooperation with MFLNRO and forest licensees the City should establish fuelbreaks in the identified areas on Iron Mountain and the Coutlee bench. | Working with Licensees and MFLNRO |

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# 1.0 INTRODUCTION

The Community Wildfire Protection Plan (CWPP) Program was created in British Columbia (BC) to aid communities in developing plans to assist in improving safety and to reduce the risk of damage to property. The Program was developed in response to recommendations from the "Firestorm 2003 Provincial Review"[1].

The 2003, 2004, 2009, and 2010, BC wildfire seasons resulted in valuable economic, social and environmental losses. These losses emphasized the need for greater consideration and due diligence with respect to fire risk in the wildland urban interface (WUI). In considering the wildfire risk in the WUI, it is important to understand the unique risk profile of a given community. While there are common themes that contribute to the risk profile of communities across BC, each community has unique aspects that require consideration during the CWPP process. Understanding the factors is important in developing a comprehensive plan to identify and reduce wildfire risk. The 2003 Okanagan Park fire and the 2011 fire in Slave Lake, Alberta demonstrated that the consequences of a WUI fire can be very significant in communities and that proper consideration and pre-planning is vital to reducing the impacts of wildfire.

In 2015, B.A. Blackwell and Associates Ltd. were retained by the City of Merritt (City) to complete an update to the original City of Merritt CWPP that was completed in 2006. Since that time, new development has occurred in addition to enhanced methods for assessing wildfire risk. This CWPP update provides a reassessment of the level of risk with respect to changes in the community and reflects the current conditions.

The objective of this update is to summarize wildfire risk recommendations from 2006 that have been implemented; identify the current main risk factors related to wildfire and provide recommendations to address communication and education, structure protection, emergency response and fuel management. To assess the risk, a Geographic Information System (GIS) model called the Wildfire Risk Management System (WRMS) was used in addition to completion of Wildland Urban Interface (WUI) Wildfire Threat Assessment Worksheets (as required by the Union of British Columbia Municipalities (UBCM)).

This CWPP update will provide the City with a framework that can be used to identify methods and guide future actions to mitigate fire risk in the community. The scope of this project included three distinct phases:

I. Assessment of fire risk and development of a Wildfire Risk Management System (WRMS) to spatially quantify the probability and consequence of fire;

II. Consultation with representatives from the City's Fire Protection Services members, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), BC Wildfire Service (BCWS), UBCM and First Nations Emergency Services Society (FNESS) to assist with defining the objectives for wildfire protection, and to develop the mitigation strategy alternatives that would best meet the City's needs.

[1] http://bcwildfire.ca/History/ReportsandReviews/2003/FirestormReport.pdf

III. Development of the Plan which outlines measures to mitigate the identified risk through communication and education programs, structure protection, emergency response and management of forestlands adjacent to the community.

# 2.0 COMMUNITY WILDFIRE PROTECTION PLANNING PROCESS

This CWPP document will review the background information related to the study area which includes the City of Merritt boundary, a 2 km buffer around the City boundary, the Merritt Fire Protection Area and additional areas that were identified around the Coldwater Indian Reserve. These were included in order to account for previous fuel treatment activities in these areas. The CWPP update consists of five general phases:

1. Background research - general community characteristics, such as demographic and economic profiles, critical infrastructure, environmental and cultural values, fire weather, fire history, relevant legislation and land jurisdiction.
2. Field work - site visits to the area allow for 1) meetings with City staff; 2) fuel type verification; 3) completing hazard assessment forms, and 4) identification of site specific issues.
3. GIS analyses - digital fuel typing and mapping of probability and consequence of fire, and community wildfire risk.
4. Report and map development - identification of City challenges and successes, identification of measures to mitigate risks, and recommendations for action.
5. Report review - by City staff, representatives from the Thompson Nicola Regional District, Cascade Forest District, BCWS, Lower Nicola Indian Band and Coldwater Indian Band.

The compiled information on the study area is used in a spatial model (WRMS). The output of the WRMS is a series of maps that characterize the probability of fire and the potential consequences of fire. The final map is a combination of all the probability and consequence layers and shows the levels of risk in the community. This is called the community risk profile, and reducing the level of risk is the main focus of the CWPP. The Action Plan (Section 8.0) specifically addresses the four elements of a CWPP that contribute to risk reduction. The four elements are emergency response, vegetation management, public education/outreach, and structure protection. This document makes specific recommendations (planning tools) on how risk can be reduced by making changes to these four elements.

# 3.0 COMMUNITY PROFILE

The City of Merritt is located in the southern interior of BC in the Nicola Valley and is 45 minutes south of Kamloops and 1.5 hours west of Kelowna. Highway 5 and Highway 97C intersect in the City and the City acts as a major gateway between the Coast and Interior of the Province. The proposed study area includes the traditional territory of the Lower Nicola Indian Band and the Coldwater Indian Band. The Nicola River extends along the southwest boundary of the City and meets the Coldwater River. The City's population is approximately 8,000 and includes both urban and rural properties with a population density of approximately 320/km$^2$. The City is composed of five residential areas which include the Bench, Colletville, Central and Diamondvale, and the City extends over 2,627 ha.[2]

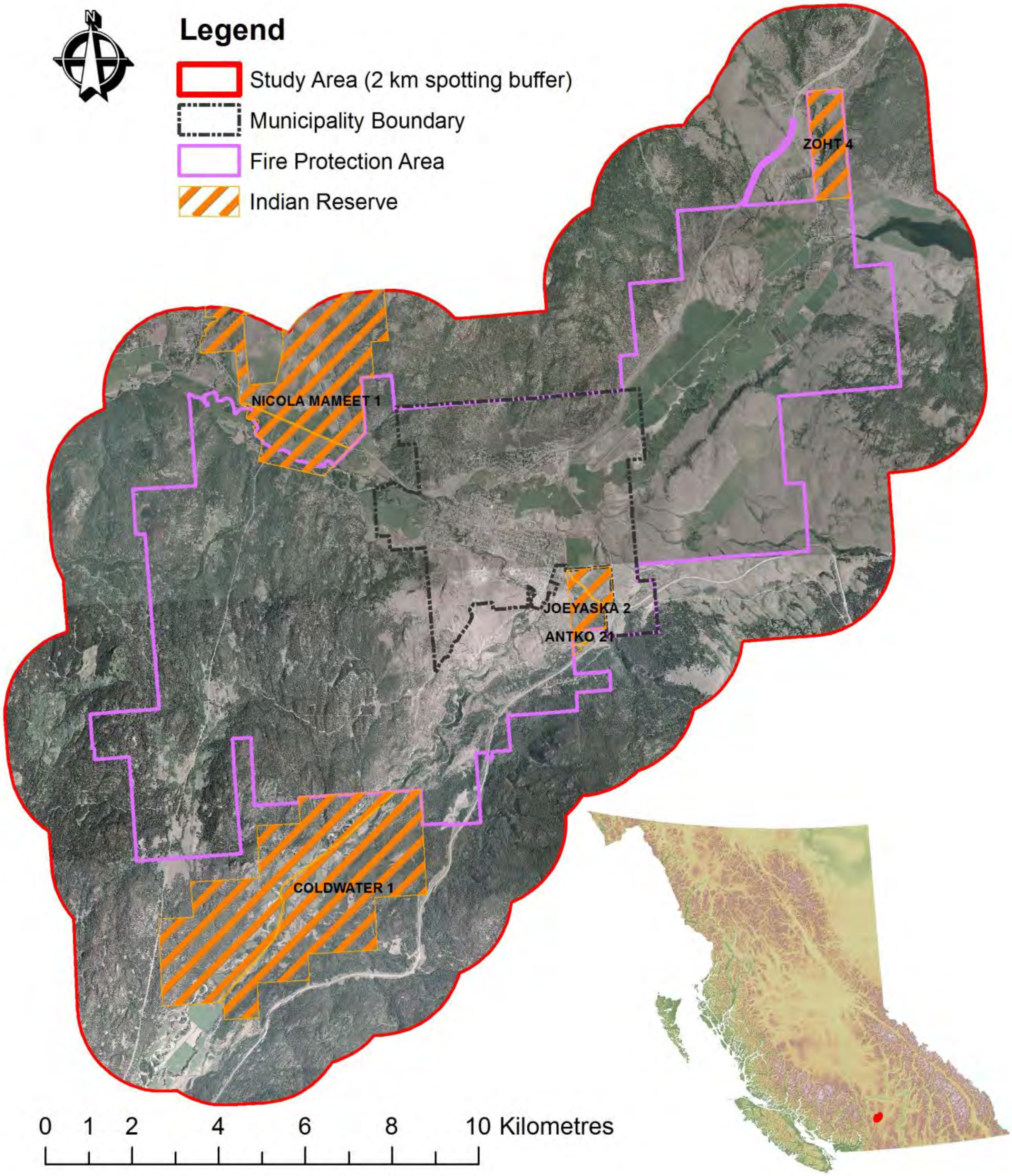
The primary industries in the community include ranching, farming, forestry, transportation and tourism, and currently a new bioenergy facility is being constructed. The City is also home to the Provincial Wildfire Training Centre and Merritt Fire Zone office. The Wildfire Training Centre is utilized annually for training wildland fire fighters. The City's Fire Protection Services offer a 12-month Work Experience Program that trains structural firefighters.[3] Additionally, the City offers a broad range of art and recreational opportunities including hosting several large music festivals which bring thousands of people into the City over several days. Recreational opportunities in the study area include but are not limited to golfing, mountain biking, dirt biking, fishing, cross-country skiing and snowmobiling. Considering the extent of recreational activities available around the City, there are extensive off-road routes (access) throughout the community with year-round access. The City and surrounding area are also home to a number of historical sites such as the Coldwater Hotel, Quilchena Hotel, Baillie House, Douglas Lake Ranch and Nicola Ranch.[4]

An overview of the City of Merritt and the study area is illustrated below (Map 1).

[2] https://en.wikipedia.org/wiki/Merritt,_British_Columbia

[3] http://www.merrittfirerescue.com/WEP_information.html

[4] http://www.merritt.ca/discover-merritt/historical-sites




**Map 1. Overview of the Community Wildfire Protection Plan Update study area for the City of Merritt. Note – the Coldwater Indian Reserve is in the process of developing an independent CWPP. Nicola Mameet 1 Indian Reserve extends beyond study area boundary.**

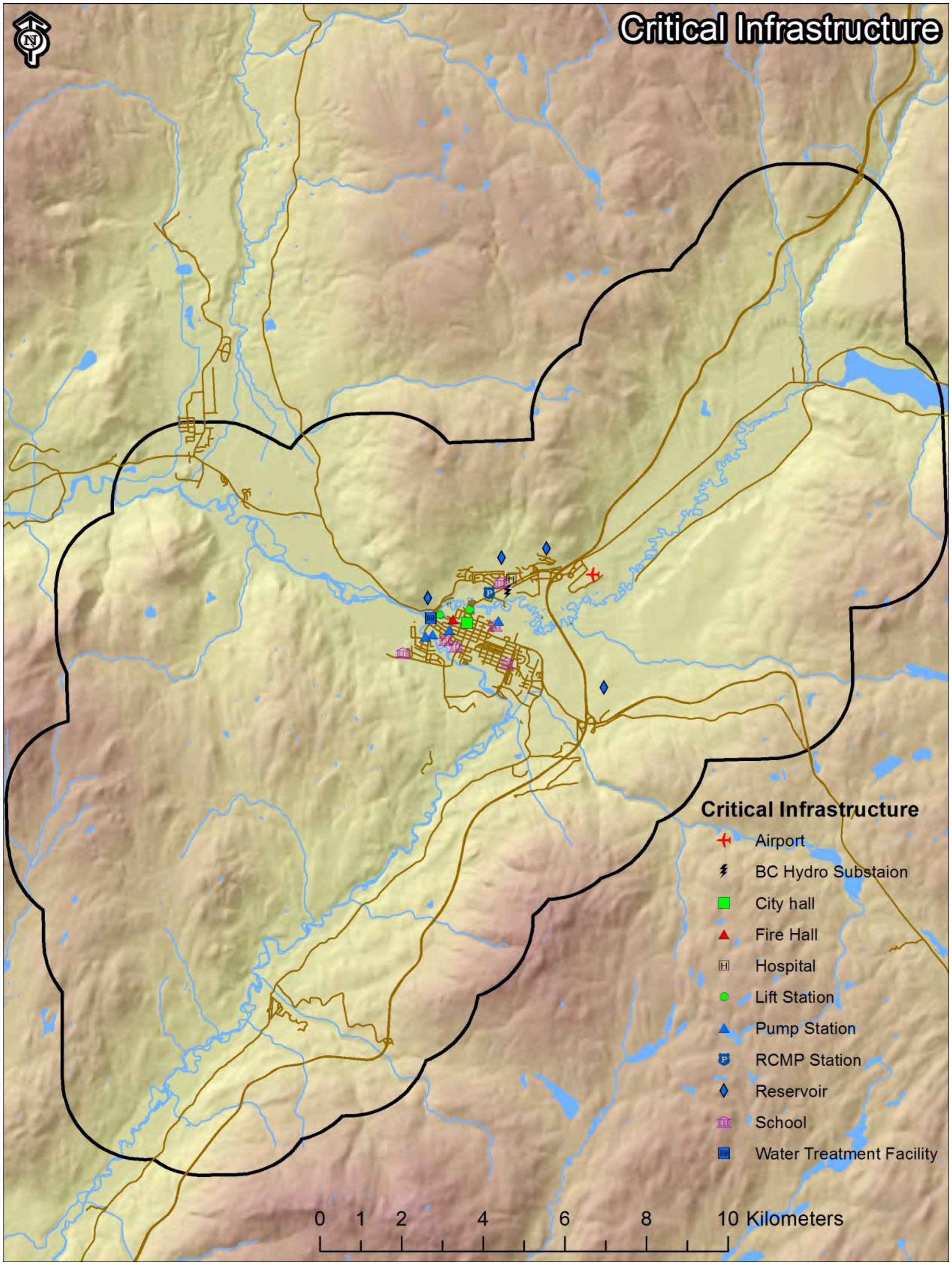
## 3.1 INFRASTRUCTURE

Protection of infrastructure during a wildfire event is important to ensure that emergency response is as effective as possible, to ensure coordinated evacuation can occur if necessary, and essential services in the study area can be maintained and/or restored quickly. Critical infrastructure includes emergency services, water, electrical service, transportation, and communications infrastructure. Additional critical infrastructure includes schools and government offices. Critical infrastructure locations were provided by the City and are illustrated below (Map 2).

Emergency services within the study area include one R.C.M.P. detachment, 911 service (police, ambulance or fire), the Nicola Valley Hospital and Health Centre Laboratory, the Merritt Fire Rescue Department, Coldwater Indian Band Fire Department and the Lower Nicola Indian Band Fire Department. The City of Merritt Fire Department is located at 1799 Nicola Avenue and currently has 32 paid-on-call members with three career officers. As noted above, the City is also home to the Merritt Fire Zone base which has five full-time staff and 53 seasonal staff (fire officers, four initial attack crews and two sustained action unit crews). Through the Thompson Nicola Regional District, the City has a local fire service agreement with a mandate to action structure fires only; however, the City Fire Department is currently actioning grass fires beyond their protection area with no cost recovery agreements.

The City Fire and Rescue Department have 32 paid-on-call members led by three career officers. Not all members are certified to the NFPA 1001 Fire Standard, however, it is a goal of the Department.

Electrical service for the study area is received through a network of wood pole transmission and distribution infrastructure supplied through BC Hydro. Wood pole distribution lines (small, street-side poles) connecting homes and subdivisions would be vulnerable to fire, which could disrupt service to portions of the community. The City owns, operates and maintains water and sewer infrastructure. The City's water system includes wells that extract water from an aquifer located under the City and there are currently four gravity-fed reservoirs that can store up to 5.5 million liters of water that is pumped from the aquifer. Only one of the five well pumps has a back-up generator.




**Map 2. City of Merritt critical infrastructure locations.**

## 3.2 ENVIRONMENTAL & CULTURAL VALUES

Environmental, cultural and recreational values are high throughout the study area. The City offers a range of outdoor activities for tourists and residents, and cultural values within the study area include the Coldwater Indian Band and Lower Nicola Indian Band traditional lands which comprise fish bearing habitat and sites of cultural significance. Other values within the study area include heritage buildings, Crown and private forest lands, and land that is administered by the Provincial Agricultural Land Commission (ALC), where the ALC is responsible for the administration of the *Agricultural Land Commission Act*. This land is part of the Agricultural Land Reserve (ALR). Subdivision and land use within the ALR is regulated by the ALC and the priority use of this land is for agriculture.[5] The ALR lands, which include farmed, forested or vacant lands, are valuable to the community and the Province. A significant wildfire would result in an impact on various values at risk throughout the study area, including valuable forest and farmland.

The Conservation Data Centre (CDC), which is part of the Environmental Stewardship Division in the Ministry of Environment, is the repository for information related to plants, animals and ecosystems at risk in BC. To identify species and ecosystems at risk within the study area the CDC database was referenced. Two classes of data are kept by the CDC: non-sensitive occurrences for which all information is available (species or ecosystems at risk and location); or masked sensitive occurrences where only generalized location information is available. One masked species occurs in the study area and no non-masked species were identified.

All future fuel treatment activities or activities associated with recommendations made in this plan should consider the presence and impact on potentially affected species. Additionally, any developed fuel management prescriptions or fuel breaks should identify any relevant masked species (sensitive occurrences) and manage fuel treatment activities to mitigate any potential impacts on species at risk.

## 3.3 BIOGEOCLIMATIC UNITS

The Biogeoclimatic Ecosystem Classification (BEC) system describes zones by vegetation, soils and climate. Regional subzones are derived from relative precipitation and temperature. The study area is defined by three Regional subzones[6]:

- IDF: The interior Douglas-fir zone (IDF) has a continental climate that is generally characterized by warm, dry summers, a long growing season, and cool winters with snowfall. The landscape in this zone is occupied by mature forests of pure Douglas-fir and where recent crown fires have occurred stands may be a mix of Douglas-fir, lodgepole pine, and ponderosa pine.

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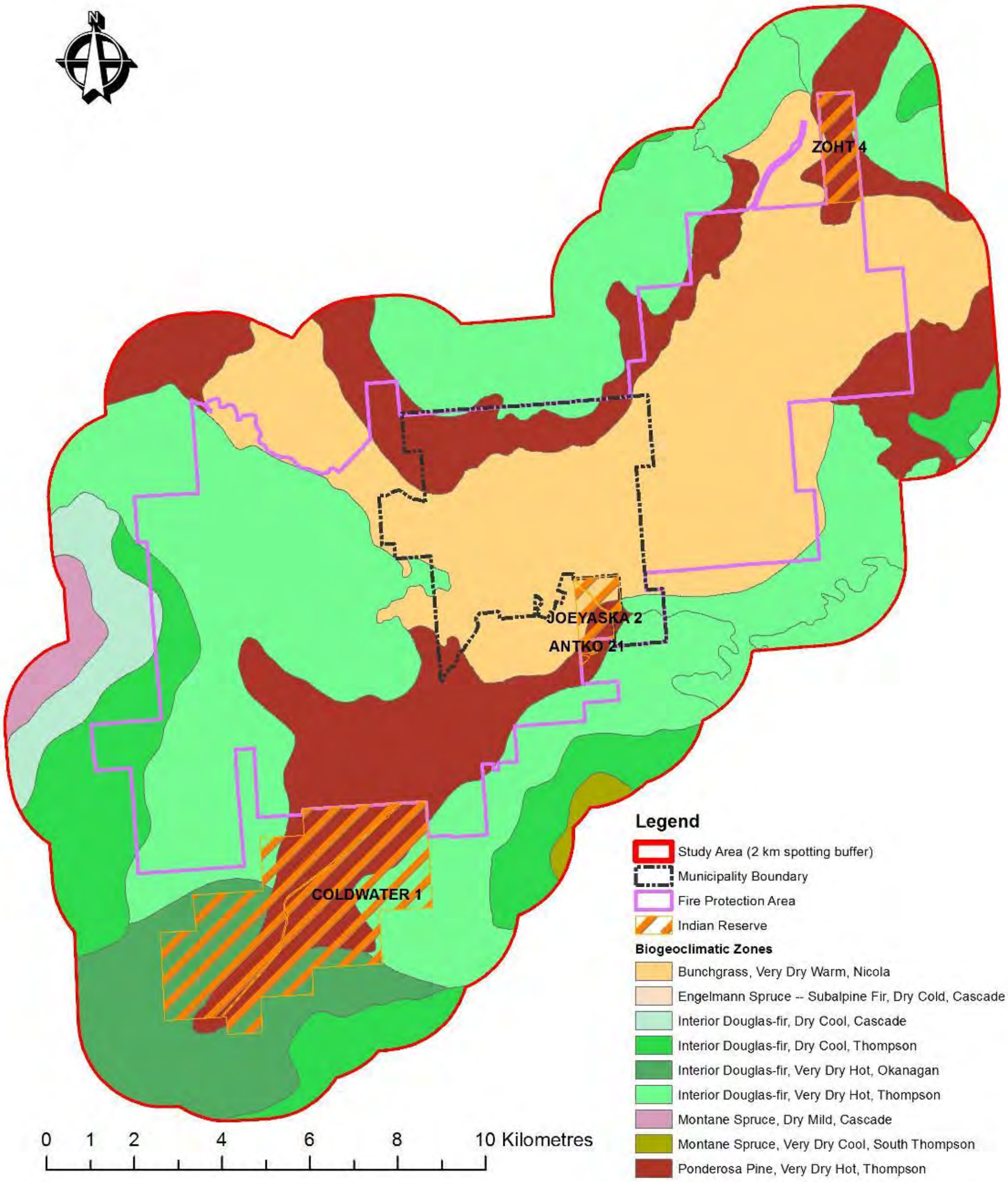
[5] http://www.alc.gov.bc.ca/index.htm

[6] Lloyd, Angove, Hope and Thompson. 1990. A Guide to Site Identification and Interpretation for the Kamloops Forest Region. Land Management Handbook #23. BC MFLNRO.

- BG: This bunchgrass zone (BG) is characterized by warm to hot, dry summers, and moderately cold winters with snowfall. Climax sites in good range condition are characterized by widely spaced bluebunch wheatgrass and a well-developed lichen crust.
- PP: The ponderosa pine zone (PP) is one of the driest zones and is also one of the warmest forested zone during summer months in BC. Winters are generally cool with snowfall. Forests in this zone often include open, parkland stand with ponderosa pine canopy and an understorey dominated by bluebunch wheatgrass, and these ecosystems can be interspersed with grassland communities.




**Map 3. Biogeoclimatic ecosystem classification zones of the City of Merritt CWPP study area.**

## 3.4 NATURAL DISTURBANCE TYPES

BEC zones have been used to classify the Province into five Natural Disturbance Types (NDTs). Natural NDTs have influenced the vegetation dynamics and ecological functions and pathways that determine many of the characteristics of our natural systems. The physical and temporal patterns, structural complexity, vegetation communities, and other resultant attributes should be used to help design fuel treatments, and where possible, to help ensure that treatments are ecologically acceptable.

The study area ecosystems are classified by ecosystems with frequent stand-maintaining fires (NDT 4). These ecosystems experience frequent low-intensity fires resulting in grasslands and open woodlands and generally in the PP zones there is a mean disturbance interval of approximately 4 – 50 years (surface fires in the PP and IDF) or ~150 – 250 for stand-initiating crown fires in the PP and IDF.

## 3.5 PAST WILDFIRE RELATED PROJECTS

The City of Merritt has been active with respect to community wildfire planning. As mentioned above, the City completed a CWPP in 2006 and they have implemented some of the recommendations outlined in that plan. Implemented recommendations are summarized below:

Operational Fuel Management:

- Aspen Planers treated 72 ha to eliminate mountain pine beetle killed trees and reduce wildfire risk on the Bench between 2005 and 2006.
- In 2006/2007, the City's Healthy Forest UBCM Proposal (Phase I) was approved and included the delineation of a treatment area of approximately 190 ha.
- Treatment of the area identified in Phase I was completed during Phase II and included treatment of area on the Bench and Coutlee area. Treatments included the removal of mountain pine beetle impacted trees and fuel reduction during Phase II of the program between 2008 and 2009.

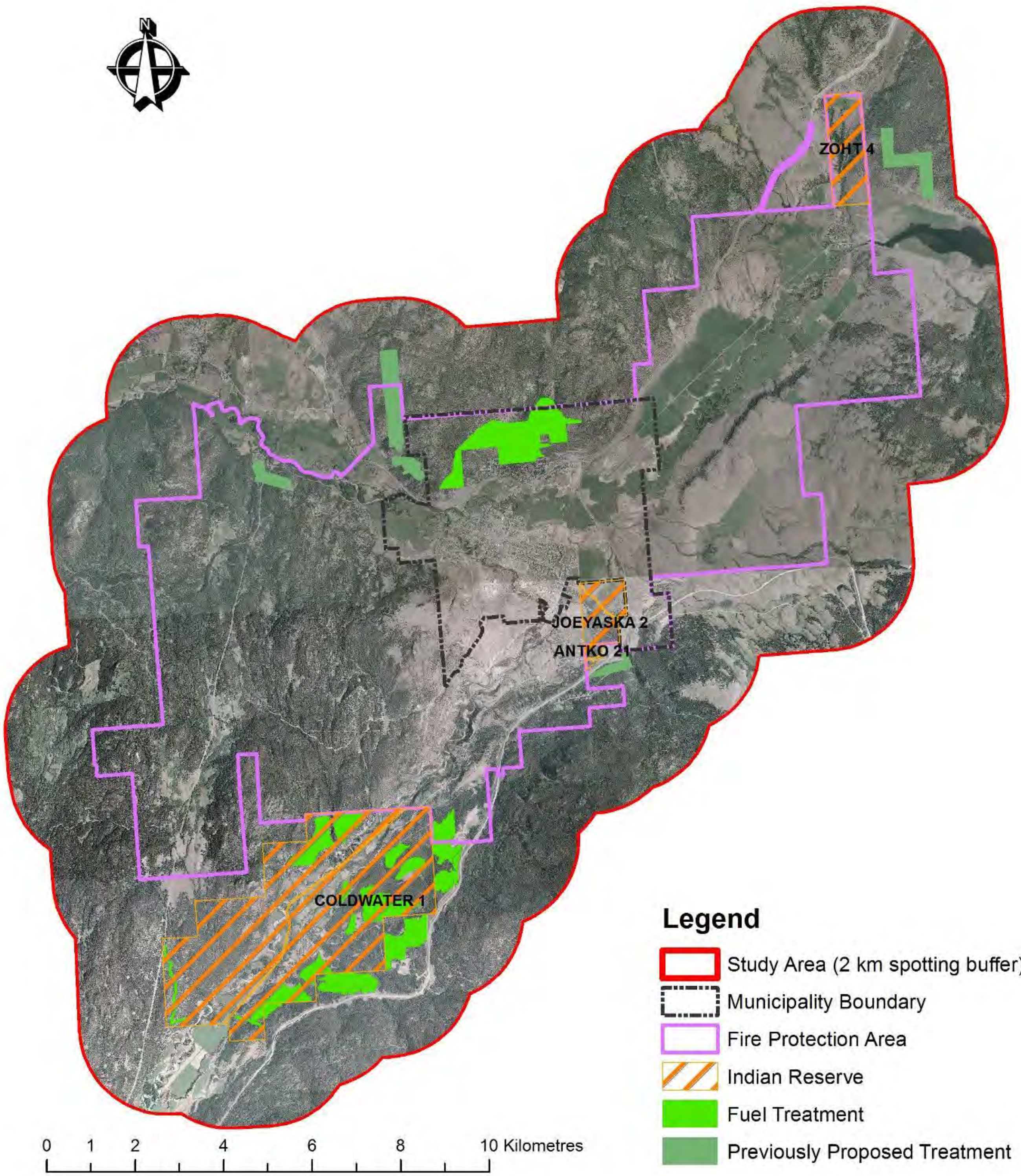
Emergency Response:

- In 2010, fire response equipment was purchased for perimeter protection and burning support (hose and sprinklers).

Community Education:

- Completed door-to-door public communication for a past fuel management program;
- During Phase I of the Health Forest UBCM program, private landowners were encouraged to mitigate the wildfire hazard on their properties (at their own cost) between 2008 and 2009.

A summary of previously treated areas is outlined below (Map 4).




**Map 4. Past fuel treatment areas that have occurred in the study area between 2005 and 2015.**

## 3.6 FOREST HEALTH

The mountain pine beetle (*Dendroctonus ponderosae*) epidemic was one of the most significant forest health factors that have impacted the study area; however, the area affected by mountain pine beetle has continually decreased over the past five years. As of 2014, it was estimated that the mountain pine beetle impacted 1,263 ha in the Merritt Timber Supply Area (TSA). The height of the epidemic occurred between 2003 and 2009 in the Southern Interior and at the peak of the infestation in 2007 approximately 5.4 million ha had been infested.

Bark beetle activity in the Merritt TSA includes Douglas-fir beetle (*Dendroctonus pseudotsugae*), spruce beetle (*Dendroctonus rufipennis*) and western balsam bark beetle (*Dryocoetes confusus*). All bark beetle activity is generally within endemic levels; however, western balsam bark beetle was slightly higher having impacted approximately 11,400 ha in 2014. In addition to biotic forest health damage, the Merritt area typically experiences abiotic damage from wildfire or windthrow; however, as of 2014 neither of these abiotic impacts were significant.

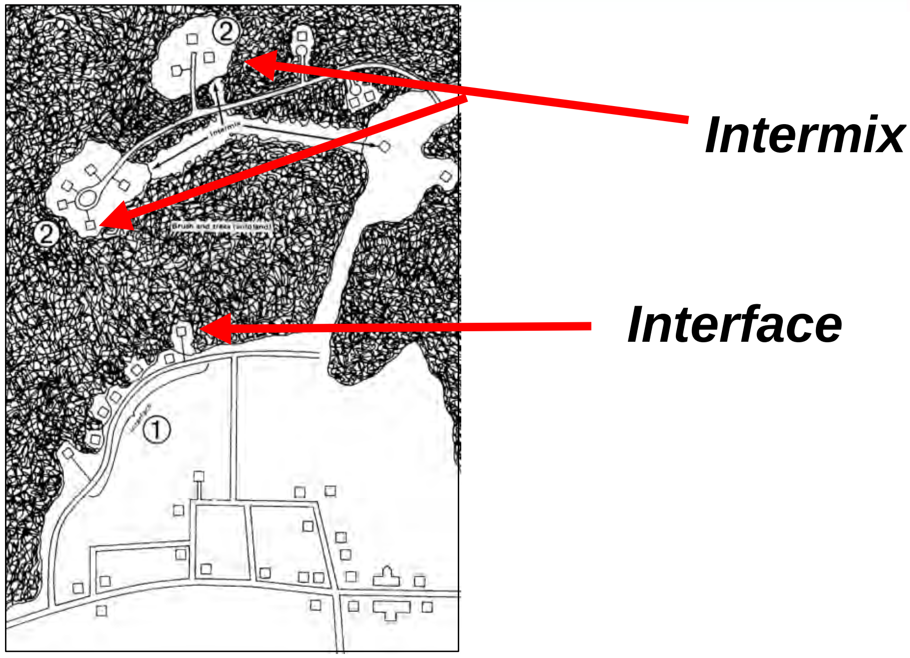
## 3.7 TIMBER HARVESTING LANDBASE

The Merritt Timber Supply Area (TSA) surrounds the City of Merritt and covers approximately 1.13 million ha and the current timber harvesting landbase was just over 600,000 ha as of 2012. Approximately 71% of this area is considered productive forest that is beyond the boundaries of Indian Reserves, private lands, woodlots and parks or ecological reserves. The Merritt TSA includes the Vermillion Forks Community Forest (13,000 ha). Twenty two percent of the productive forest within the Merritt TSA is not available for timber harvesting and these include the following areas: parks and protected areas; environmentally sensitive areas; problem forest types; inoperable areas; archaeological concerns; riparian reserves; heritage trails; and wildlife tree reserves and Old Growth Management Areas. The timber harvesting landbase is dominated by pine, Douglas-fir, spruce and true fir.

# 4.0 THE WILDLAND URBAN INTERFACE

The WUI is generally defined as the place where the forest meets the community. There are different WUI conditions, which are variations on 'perimeter interface' and 'intermix'. A perimeter interface condition is generally where there is a clean transition from urban development to forest lands. Smaller, more isolated developments that are embedded within the forest are referred to as intermixed areas. An example of interface and intermixed areas is illustrated in Figure 1.

**Figure 1. Illustration of intermix and interface areas.**




In interface and intermixed communities, fire has the ability to spread from the forest into the community or from the community out into the forest. Although these two scenarios are quite different, they are of equal importance when considering interface fire risk. Regardless of which scenario occurs, there will be consequences for the community and this will have an impact on the way in which the community plans and prepares for interface fires.

## 4.1 VULNERABILITY OF THE WILDLAND URBAN INTERFACE TO FIRE

Fires spreading into the WUI from the forest can impact homes in two distinct ways:

1. From sparks or burning embers carried by the wind, or convection that starts new fires beyond the zone of direct ignition (main advancing fire front), and alight on vulnerable construction materials (*i.e.* roofing, siding, decks etc.) (Figure 2).

2. From direct flame contact, convective heating, conductive heating or radiant heating along the edge of a burning fire front (burning forest), or through structure-to-structure contact. Fire can ignite a vulnerable structure when the structure is in close proximity (within 10 meters of the flame) to either the forest edge or a burning house (Figure 3).


**Figure 2. Firebrand caused ignitions: burning embers are carried ahead of the fire front and alight on vulnerable building surfaces.**

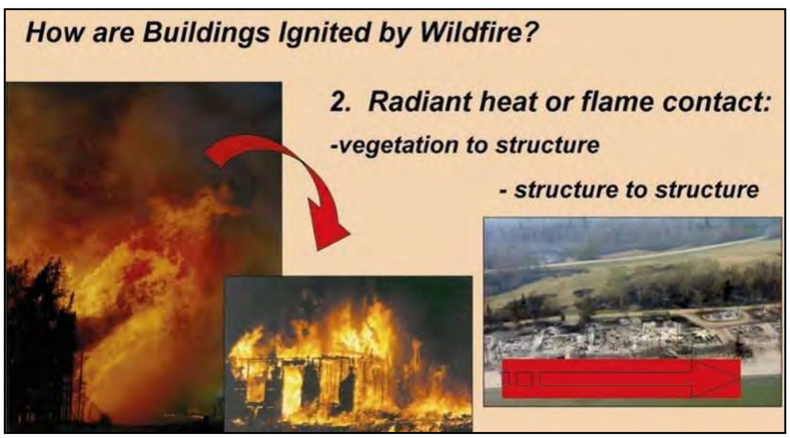



**Figure 3. Radiant heat and flame contact allows fire to spread from vegetation to structure or from structure to structure.**

# 5.0 FIRESMART

One of the most important areas with respect to forest fire ignition and the damages associated with a wildfire is the zone adjacent to buildings and homes. *FireSmart, Protecting Your Community from Wildfire*[7] is a guide developed by Partners in Protection that provides practical tools and information on how to reduce the risk of loss from interface fires. The FireSmart website can be visited at: www.firesmartcanada.ca.

We often consider wildfire an external threat to our residences; however in many cases fire can originate as a house fire and spread into the interface. Regardless of the origin of the fire, home owners and businesses can take steps

[7] For further information regarding the FireSmart program see *www.pep.bc.ca/hazard_preparedness/FireSmart-BC4.pdf*

to reduce the probability of this occurring. There are two main avenues to FireSmart a home: 1) change the vegetation type, density, and setback from the building (fuel treatments and landscaping) and 2) change the structure to reduce vulnerability to fire and the potential for fire to spread to or from a building.[7]

## 5.1 FIRESMART STRUCTURE PROTECTION

An important consideration in protecting the WUI zone from fire is ensuring that homes can withstand an interface fire event. Often, it is a burning ember traveling aloft and landing on vulnerable housing materials (spotting), rather than direct flame contact (vegetation to house) or radiative heat that ignites a structure. Alternatively, the convective or radiant heat produced by one structure may ignite an adjacent structure if it is in close proximity. Structure protection is focused on ensuring that building materials and construction standards are appropriate to protect individual homes from interface fire. Materials and construction standards used in roofing, exterior siding, window and door glazing, eaves, vents, openings, balconies, decks, and porches are primary considerations in developing FireSmart neighbourhoods. Housing built using appropriate construction techniques and materials are less likely to be impacted by interface fires.[7]

While many BC communities established to date were built without significant consideration with regard to interface fire, there are still ways to reduce home vulnerability. Changes to roofing materials, siding, and decking can be achieved over the long-term through changes in bylaws and building codes. The FireSmart approach has been adopted by a wide range of governments and is a recognized process for reducing and managing fire risk in the wildland urban interface. The most important components of the FireSmart approach are the adoption of the hazard assessment systems for wildfire, site and structure hazard assessment, and the proposed solutions outlined for fuel management, structure protection, and infrastructure. Where fire risk is moderate or greater, at a minimum, the FireSmart standard should be applied to new subdivision developments and, wherever possible, the standard should be integrated into existing subdivisions and built up areas when renovations occur or landscaping is changed.

A Wildfire Hazard Development Area for subdivision or land use applications that will create four or more parcels or dwelling units was developed for the Thompson Nicola Regional District (TNRD) and is outlined in the Nicola Valley Community Plan.[8] Applications within the study area must provide the TNRD with a Wildfire Hazard Assessment Report that is prepared by a Registered Professional Forester (licensed in BC). The reports assess the current wildfire hazard; assess conditions on and off-site including neighbouring lands; evaluate the proposed development for wildfire susceptibility; and provide FireSmart recommendations that will reduce the wildfire hazard below a moderate rating.

The following link accesses an excellent four minute video demonstrating the importance of FireSmart building practices during a simulated ember shower: http://www.youtube.com/watch?v=_Vh4cQdH26g.

[8] https://tnrd.civicweb.net/document/61130/Nicola%20Vally%20Official%20Community%20Paln%20(October%202011.pdf?handle=87E92D34D28A4C688F4641EB17F54F40

**Roofing Material:**

Roofing material is one of the most important characteristics influencing a home's vulnerability to fire. Roofing materials that can be ignited by burning embers increases the probability of fire related damage to a home during an interface fire event.

In many communities, there is no fire vulnerability standard for roofing material. Homes are often constructed with unrated materials that are considered a major hazard during a large fire event. In addition to the vulnerability of roofing materials, adjacent vegetation may be in contact with roofs, or roof surfaces may be covered with litter fall from adjacent trees. This increases the hazard by increasing the ignitable surfaces and potentially enabling direct flame contact between vegetation and structures.

**Building Exterior - Siding Material:**

Building exteriors constructed of vinyl or wood are considered the second highest contributor to structural hazard after roofing material. These materials are vulnerable to direct flame or may ignite when sufficiently heated by nearby burning fuels. The smoke column will transport burning embers, which may lodge against siding materials. Brick, stucco, or heavy timber materials offer much better resistance to fire. While wood may not be the best choice for use in the WUI, other values from economic and environmental perspectives must also be considered. It is significantly less expensive than many other materials, supplies a great deal of employment in BC, and is a renewable resource. New treatments and paints are now available for wood that increase its resistance to fire and they should be considered for use.

**Balconies and Decking:**

Open balconies and decks increase fire vulnerability through their ability to trap rising heat, by permitting the entry of sparks and embers, and by enabling fire access to these areas. Closing these structures off limits ember access to these areas and reduces fire vulnerability.

**Combustible Materials:**

Combustible materials stored within 10 m of residences are also considered a significant issue. Woodpiles, propane tanks and other flammable materials adjacent to the home provide fuel and ignitable surfaces. Locating these fuels away from structures helps to reduce structural fire hazards and makes it easier and safer for suppression crews to implement suppression activities adjacent to a house or multiple houses.

## 5.2 FIRESMART FUEL TREATMENTS

One effective method of reducing the ease with which fire can move to and from a home is by altering the vegetation around the home (Figure 4). The following information regarding fuel treatments is based on the FireSmart Manual (Partners in Protection 2002).

**Priority Zone 1** is a 10 m fuel free zone around structures. This ensures that direct flame contact with the building cannot occur and reduces the potential for radiative or conductive heat to ignite the building. While creating this zone is not always possible, landscaping choices should reflect the use of less flammable vegetation such as deciduous shrubs, herbs and other species with low flammability. Coniferous vegetation such as juniper or cedar shrubs and hedges should be avoided, as these are highly flammable. Any vegetation in this zone should be widely spaced and well setback from the house.

**Priority Zone 2** extends from 10 to 30 m from the structure. In this zone, trees should be widely spaced 5 to 10 m apart, depending on size and species. Tree crowns should not touch or overlap. Deciduous trees have much lower volatility than coniferous trees, so where possible deciduous trees should be preferred for retention or planting. Trees in this area should be pruned as high as possible (without compromising tree health), especially where long limbs extend towards buildings. This helps to prevent a fire on the ground from moving up into the crown of the tree or spreading to a structure. Any downed wood or other flammable material should also be cleaned up in this zone to reduce fire moving along the ground.

**Priority Zone 3** extends from 30 to 100 m from the home. The main threat posed by trees in this zone is spotting, the transmission of fire through embers carried aloft and deposited on the building or adjacent flammable vegetation. To reduce this threat, cleanup of surface fuels as well as pruning and spacing of trees should be completed in this zone (Partners in Protection 2002).

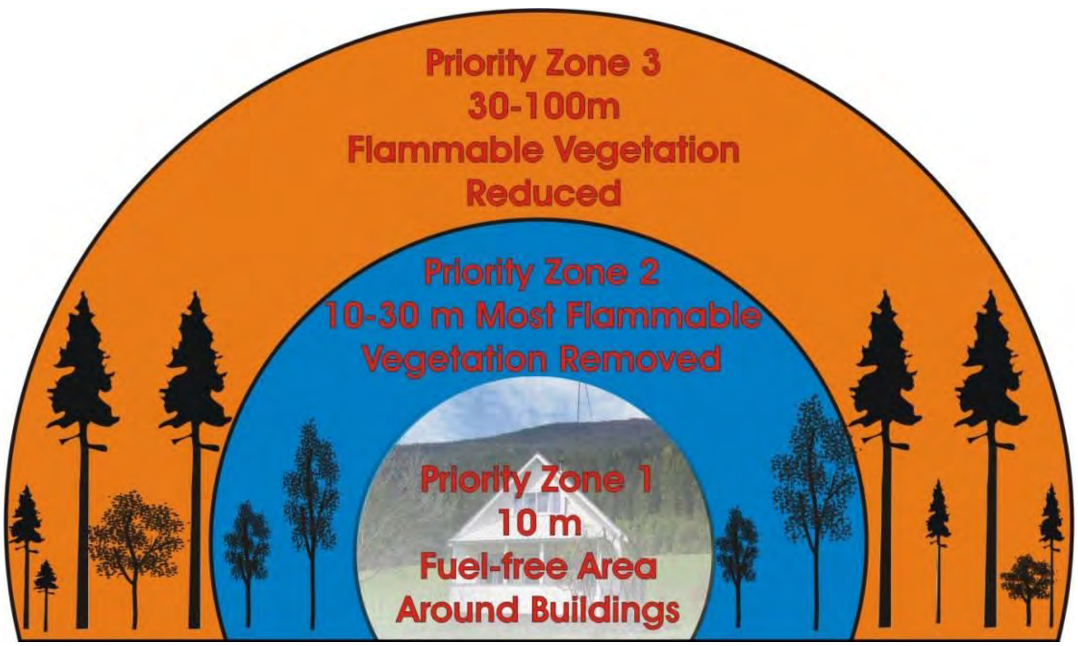



**Figure 4. Illustration of FireSmart zones.**
(Figure adapted from FireSmart)

# 6.0 FIRE ENVIRONMENT

## 6.1 FIRE WEATHER

The Canadian Forestry Service developed the Canadian Forest Fire Danger Rating System (CFFDRS) to assess fire danger and potential fire behaviour. A network of fire weather stations during the fire season are maintained by the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and are used to determine fire danger on forestlands within a community. The information can be obtained from the MFLNRO Protection Branch and is most commonly utilized by municipalities and regional districts to monitor fire weather, and to determine hazard ratings, associated with bans and closures.

Fire Danger Classes provide a relative index of how easy it is to ignite a fire and how difficult control is likely to be. The BC *Wildfire Act* [BC 2004] and *Wildfire Regulation* [BC Reg. 38/2005], which specify responsibilities and obligations with respect to fire use, prevention, control and rehabilitation, restrict high risk activities based on these classes. Fire Danger Classes are defined as follows:

- **Class 1 (Very Low)**: Fires are likely to be self-extinguishing and new ignitions are unlikely. Any existing fires are limited to smoldering in deep, drier layers.
- **Class 2 (Low)**: Creeping or gentle surface fires. Fires are easily contained by ground crews with pumps and hand tools.
- **Class 3 (Moderate)**: Moderate to vigorous surface fires with intermittent crown involvement. They are challenging for ground crews to handle; heavy equipment (bulldozers, tanker trucks, and aircraft) are often required to contain these fires.
- **Class 4 (High)**: High-intensity fires with partial to full crown involvement. Head fire conditions are beyond the ability of ground crews; air attack with retardant is required to effectively attack the fire's head.
- **Class 5 (Extreme)**: Fires with fast-spreading, high-intensity crown fire. These fires are very difficult to control. Suppression actions are limited to flanks, with only indirect actions possible against the fire's head.

It is important to highlight that the likelihood of exposure to periods of high fire danger, defined as Danger Class 4 (High) and 5 (Extreme), are important to understand in order to determine appropriate prevention programs, levels of response, and management strategies. The study area lies in an ecosystem that is characterized as 'dry interior', with low annual precipitation and high temperatures, leading to a large proportion of 'high' or 'extreme' fire danger days. Danger Class days were summarized to provide an indication of the fire weather in the study area and it is worthy to note that this is a representation of average historical fire danger in the study area, which can vary from season to season.

Considering fire danger varies from year to year, historical weather data can provide information on the number and distribution of days when the study area is typically subject to high fire danger conditions, which is useful information in assessing fire risk.

Average Danger Class days for each month of the fire season (May – September) are illustrated in Figure 5. Data was provided by the MFLNRO. Sixty-four years of data (1950 – 2014) from the Merritt weather station was used to summarize fire weather for the study area. Generally, during the fire season fire danger ratings are predominantly Moderate or higher. On average, the greatest numbers of High Danger Class (DC IV) days generally occurs during July and August, and most extreme fire weather is experienced in July. After August there is a rapid decline in the probability of high or extreme ratings.

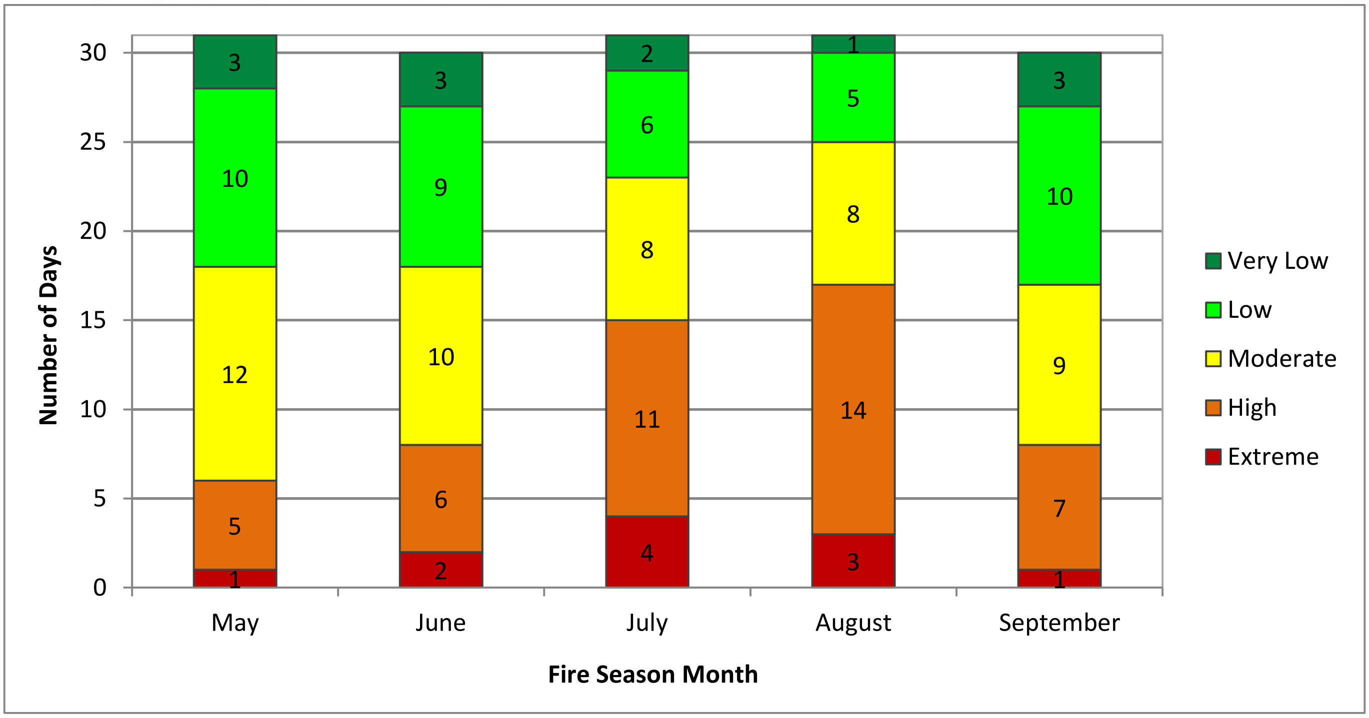


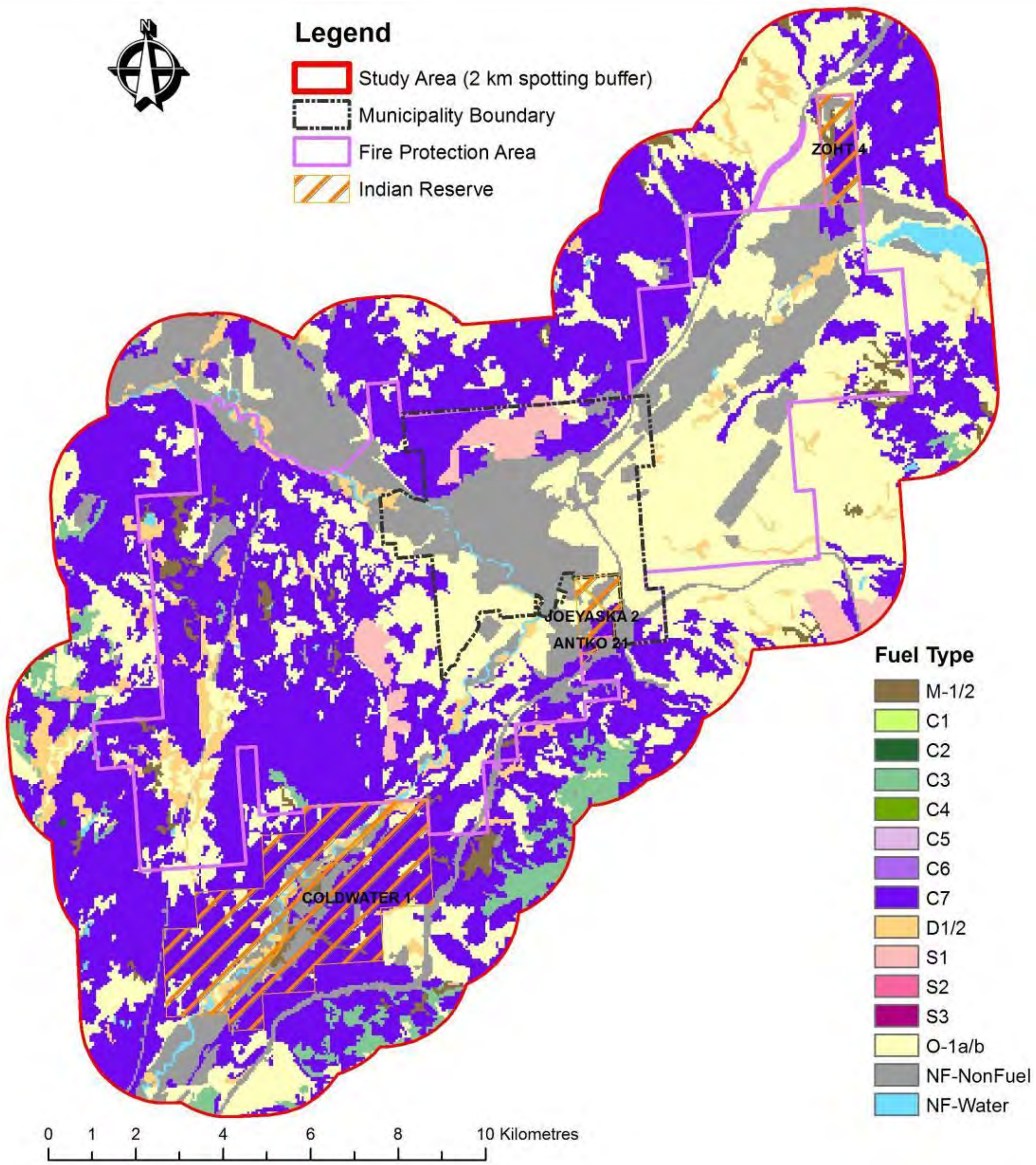

**Figure 5. Probability of Fire Danger Class ratings averaged by month over a 64-year period (1950 – 2014) from the Merritt weather station.**

## 6.2 FUEL TYPES & HISTORIC IGNITIONS

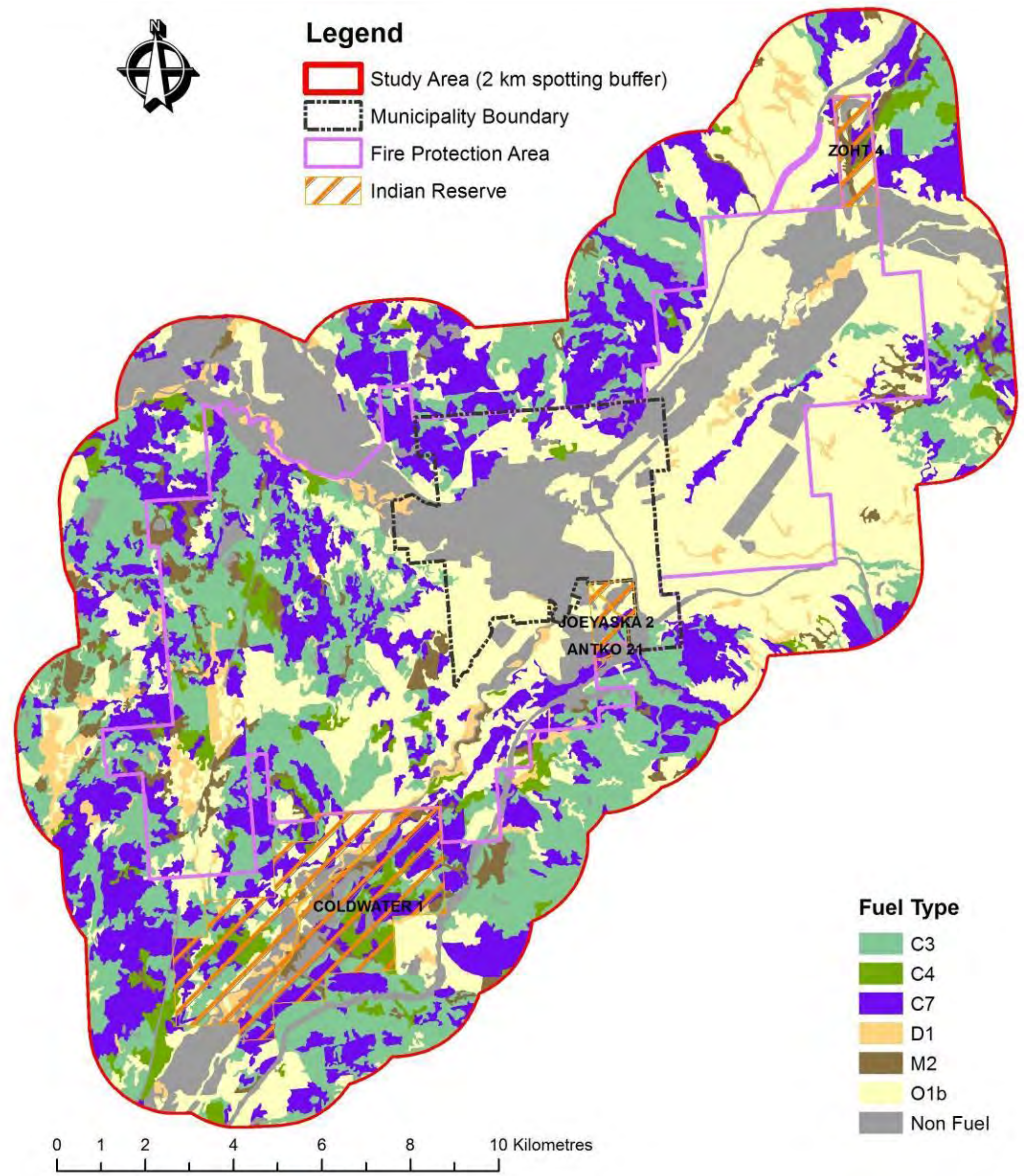
The fuel typing used to develop the Provincial Strategic Threat Analysis (PSTA) is based on inventory and information that may be outdated, therefore fuel types are generated spatially by assigning the CFFDRS fuel types based on the Vegetation Resource Inventory (VRI) data (Map 5) and updated with field fuel type verification (Map 6). The fuel types within the study area and the composition for each fuel type are outlined in Table 1. This method uses BEC, species mix, crown closure, age, and non-forest descriptors to assign fuel type. Typically, the outputs require refinement and do not adequately describe the variation in fuels present within a given area, due to errors in VRI and adjustments required in the data. For this reason, it is important to ground-truth/verify fuel types to improve fuel type accuracy. Table 1 summarizes the fuel types by general fire behaviour and total area for the study area. In general, the fuel types considered hazardous in terms of dangerous fire behaviour and spotting potential are C2, C4 and C3. An M2 fuel type can sometimes be considered hazardous, depending on the proportion of conifers within the forest stand. Map 7 illustrates the study area hazardous fuel types.

**Table 1. A summary of fuel types, associated hazard and areas within the study area.**

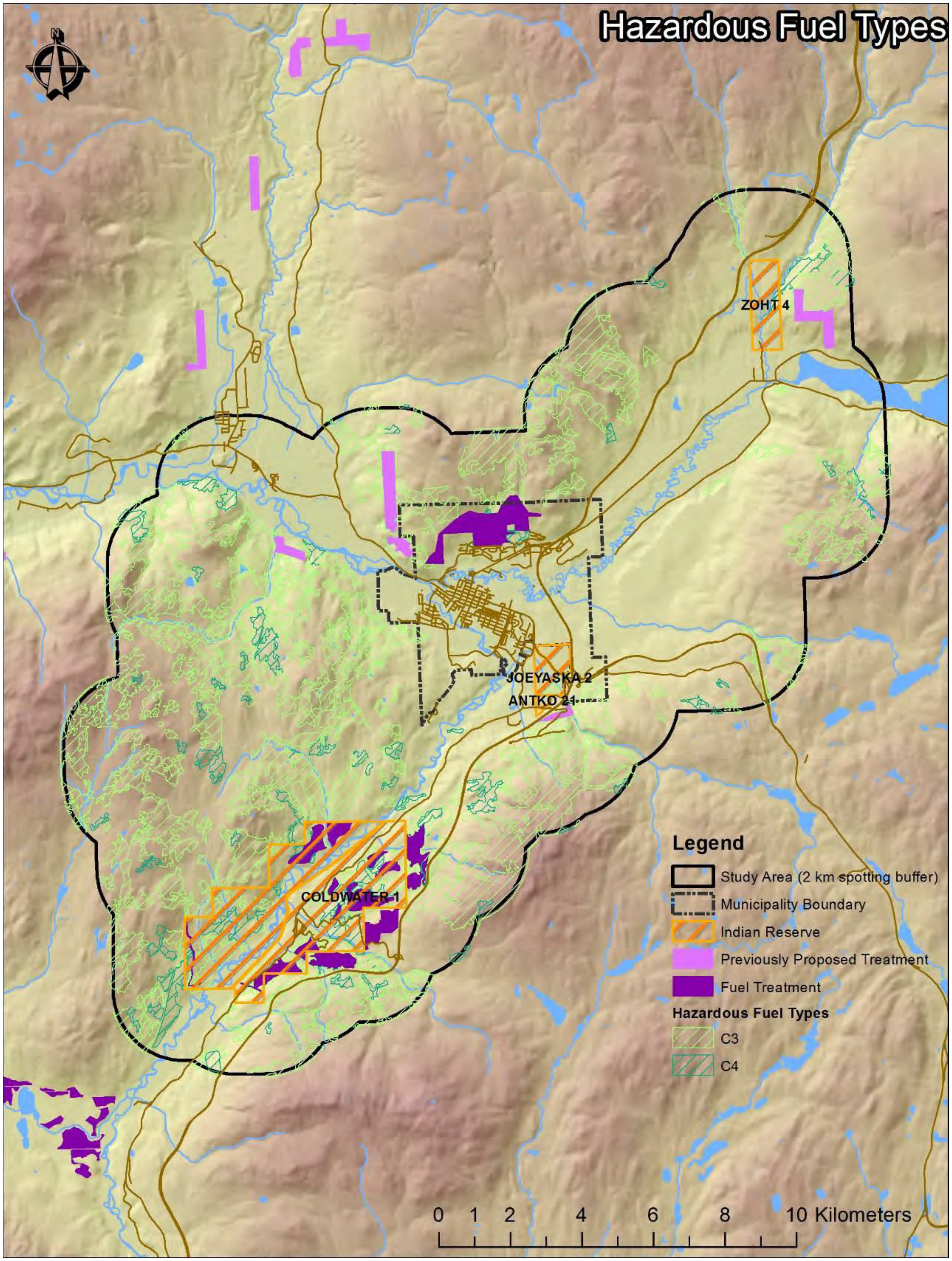
| Fuel Type | Description | Wildfire Behaviour Under High Wildfire Danger Level | Area (ha) | Percent (%) |
|---|---|---|---|---|
| C3 | Fully stocked, mature forest, crowns separated from the ground | Surface and crown fire, low to very high fire intensity and rate of spread | 7,068 | 22 |
| C4 | Dense, pole-sapling forest, high component of standing dead and down, woody fuel, continuous vertical crown fuel continuity | Almost always crown fire, high to very high fire intensity and rate of spread | 996 | 3 |
| C7 | Open, uneven-aged forest, crowns separated from the ground except in conifer thickets, understorey of discontinuous grasses, herbs | Surface fire spread, torching of individual trees, rarely crowning (usually limited to slopes > 30%), moderate to high intensity and rate of spread | 6,588 | 20 |
| M2 | Moderately well-stocked mixed stand of conifers and deciduous species, low to moderate dead, down woody fuels, crowns nearly to the ground | Surface fire spread, torching of individual trees and intermittent crowning, (depending on slope and percent conifer) | 1,011 | 3 |
| D1 | Moderately well-stocked deciduous stands | Always a surface fire, low to moderate rate of spread and fire intensity | 961 | 3 |
| O1b | Sparse or scattered shrubs and down woody fuels. | Rapid spreading, intense surface fire | 10,355 | 32 |
| NF | Non-fuel | N/A | 5,257 | 16 |
| | | **Total:** | **32,237** | **100%** |




Map 5. Provincial fuel types for the study area.




Map 6. Updated/ground-truthed fuel types for the study area.




**Map 7. Hazardous fuel types (C3 and C4) that occur in the study.**

Fuel type ground truthing included data collection and was completed throughout the study area on July 12, 2015. Predominant fuel types were 01b, C3 and C7. At fuel typing points the following attributes were assessed: structure classification; dominant tree species; tree species type and composition (%); understorey vegetation; average age; average overstorey height; stand density; crown closure; height to live crown separation; surface fuel loading; burn difficulty; and forest floor and organic layer. A number of field stops were completed to assess fuels (Figure 6).

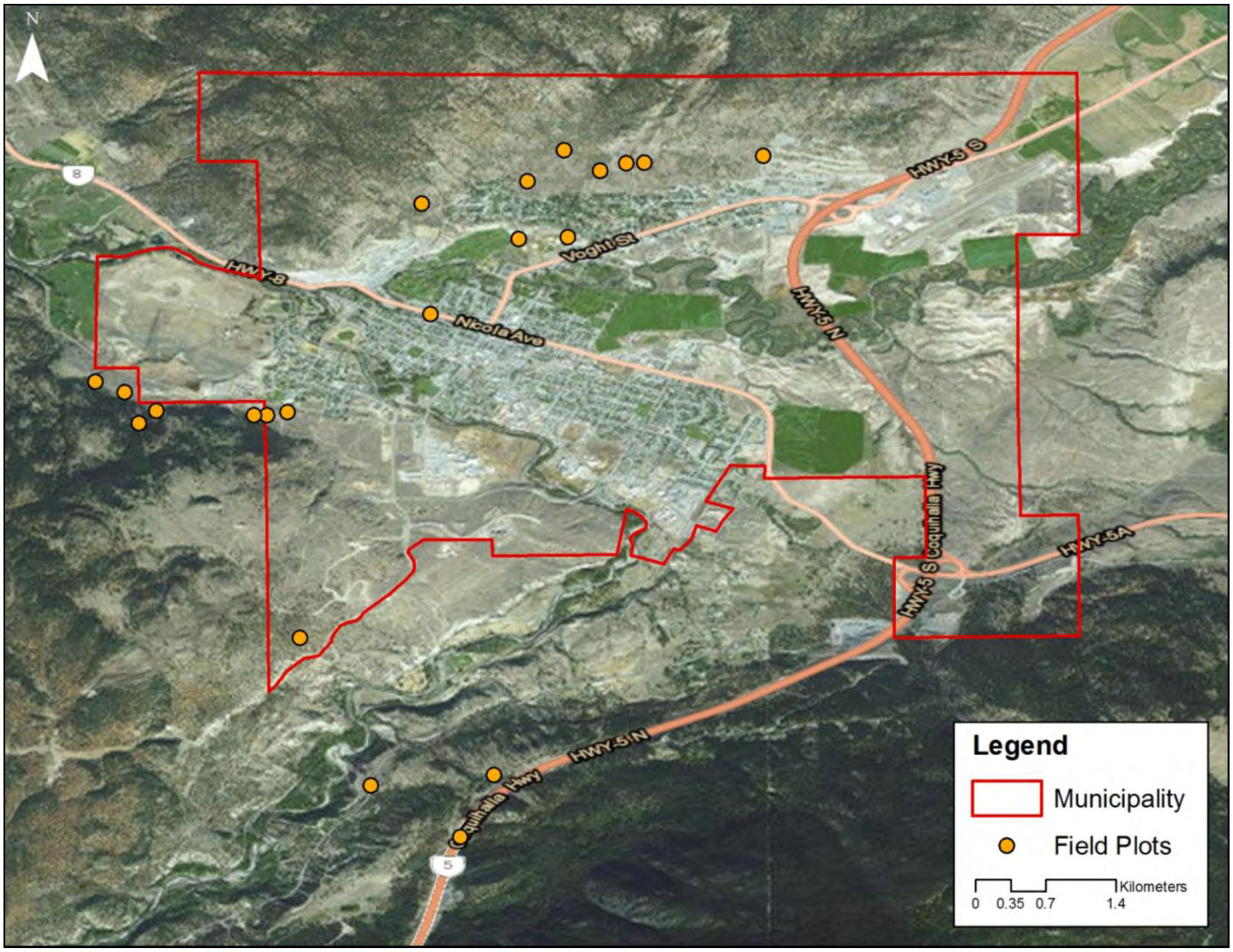



**Figure 6. Field assessment points.**

*WUI Wildfire Threat Assessments*[9] were completed in select interface developments to support identification of high wildfire risk areas (Table 2; Figure 7). The *WUI Threat Assessment* worksheets and plot locations are provided as a separate document. The *WUI Threat Assessments* do not address issues with structures; rather, this system assesses the fuel hazard immediately adjacent to developments and extends into the wildland. Fuel, weather, topography and structural components are assessed.[9] Additionally, potential fuelbreak opportunities were assessed and based on professional judgment. Two potential fuelbreak locations were identified and considered due to wildfire potential and prevailing wind directions. This included local concerns of a potential catastrophic wildfire moving through the Nicola Valley and moving into the City from ember showers or by moving through the continuous forested landbase. Fuelbreaks were located with consideration of existing physical features such as roads, cutblocks/clearings and right-of-ways.

**Table 2. Wildland urban interface threat worksheet summaries for the study area.**

| WUI Plot | Geographic Location | WUI Threat Worksheet Components | | | | Wildfire Behaviour Threat Class (/240) | WUI Threat Class (/55) | Total Threat Score (/295) |
|---|---|---|---|---|---|---|---|---|
| | | Fuel | Weather | Topography | Structural | | | |
| 1 | Peregrine Way | 48 | 25 | 42 | 35 | 115 (High) | 35 (High) | 150 |
| 2 | Allen Road | 40 | 25 | 42 | 35 | 107 (High) | 35 (High) | 142 |
| 3 | Pineridge Drive | 40 | 25 | 40 | 37 | 105 (High) | 37 (High) | 142 |
| 4/5 | Central Park | 27* | 25 | 38 | 48 | 90 (Moderate) | 48 (Extreme) | 138 |
| 9 | Collettville School (Fuelbreak) | 42 | 30 | 32 | 28 | 104 (High) | 28 (High) | 132 |
| 11 | Logan Lane (Fuelbreak) | 48 | 25 | 39 | 40 | 112 (High) | 40 (Extreme) | 152 |

*** Concerns with human-caused grass fires moving rapidly to adjacent homes from this high use park.**

[9] http://www.ubcm.ca/assets/Funding~Programs/LGPS/Current~LGPS~Programs/SWPI/Resources/swpi-WUI-WTA-Guide-(2012-Update).pdf

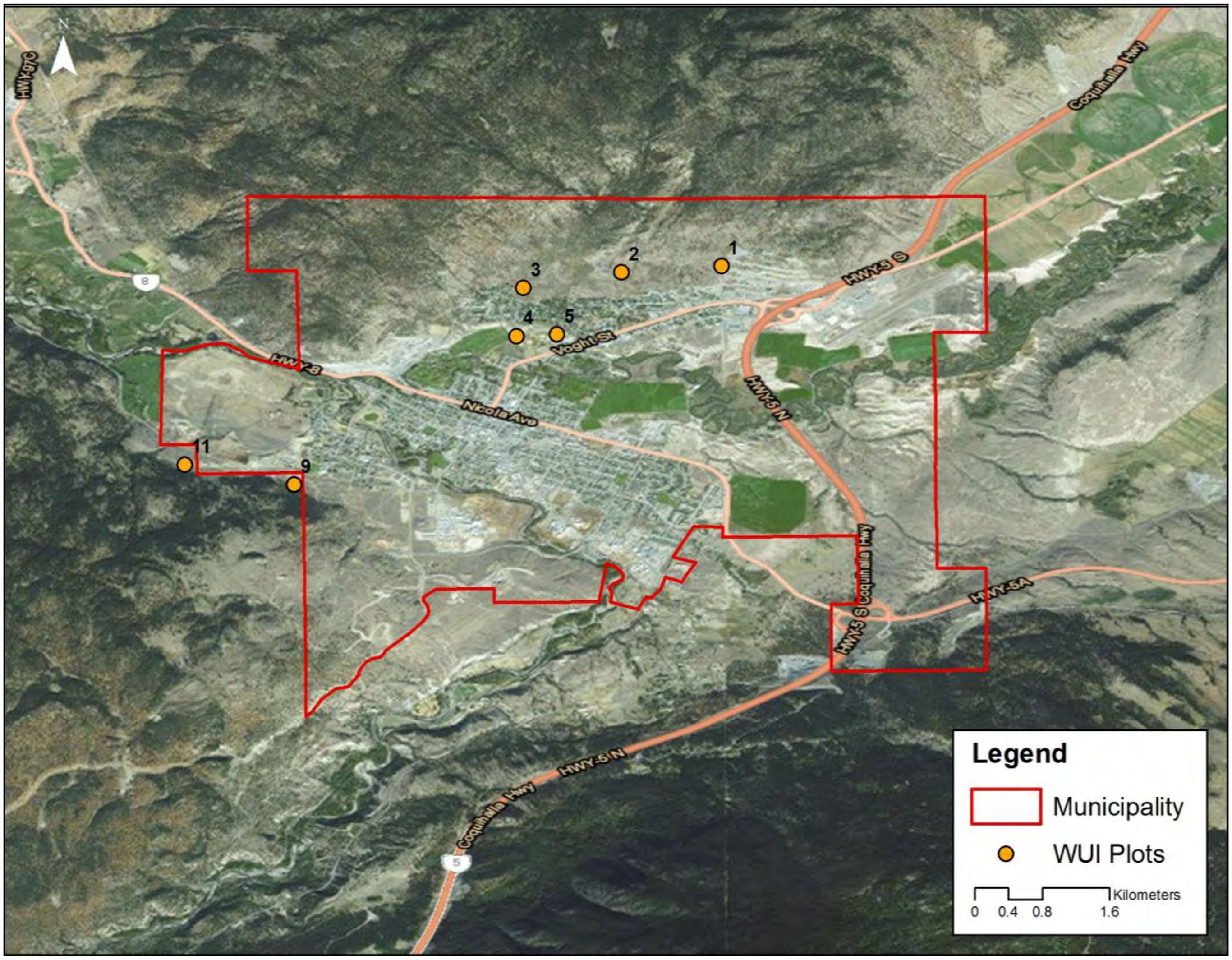



**Figure 7. Wildland urban interface threat assessment plots.**

The *Wildfire Behaviour Threat Class* provides an estimate of the potential wildfire behaviour of the area. The plots completed were primarily in the 'High' class. A high rating suggests the area is generally forested with continuous surface fuels that can support crown fires and includes areas with steeper slopes and with a southerly and/or westerly aspect.[9] The assessed areas were generally grass/shrub ecosystems backing into continuous forest with the potential for rapidly spreading ground fires and crown fires where tree density is high.

The *WUI Threat Class* is generally only assessed when the *Wildfire Behaviour Threat Class* is assessed as 'High' or 'Extreme'. Areas that are rated 'High' or 'Extreme' in the *WUI Threat Class* are within close proximity (within 500 m or directly adjacent) to a community or development.[12] For this project the *WUI Threat Class* was assessed for Central Park although the *Wildfire Behaviour Threat Class* score was Moderate. The Park was assessed to determine the potential wildfire threat posed to the adjacent homes considering this is a high use area and the threat of a fire is considered high.

**Figure 8. Central Park and homes located at the top of the slope.**

Areas identified with a *Wildfire Behaviour Threat Class* and *WUI Threat Class* greater than High and recommended for fuel treatment or fuelbreak development were:

- North side of the City – fuel mitigation and fuel treatment maintenance throughout the area surrounding/north of Peregrine Way, Allen Road and the new development around Pineridge Drive (Figure 9); and
- West side of the City (Coutlee Bench) – fuel treatment/fuelbreak establishment in the area east of Collettville School and the new development around Logan Lane (Figure 10).

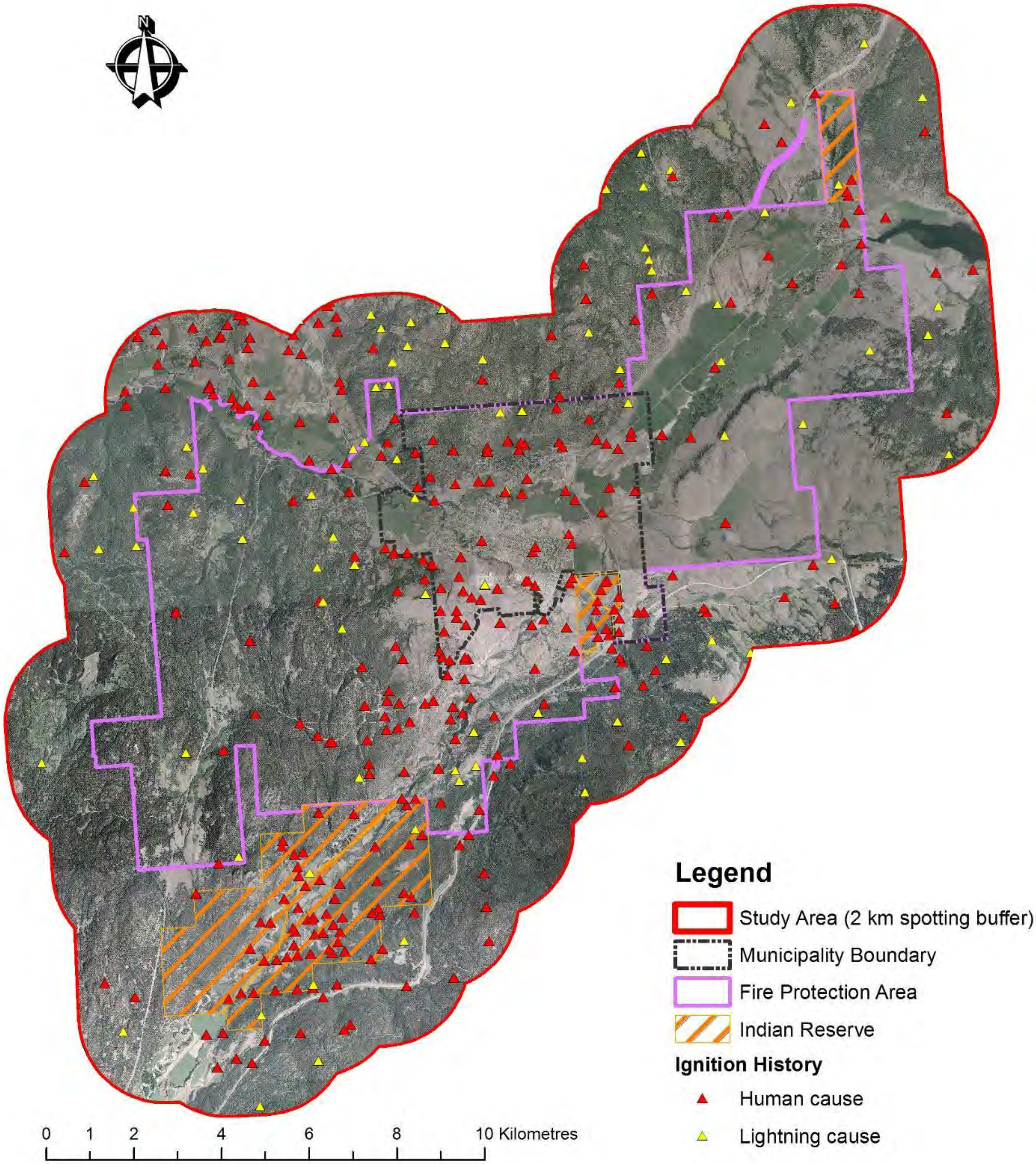
Fuelbreak establishment is also recommended for the area on Iron Mountain considering the risk to critical infrastructure (communication tower) and strategic planning to reduce the risk of a landscape level fire moving into the community. Considering this area is not within the immediate wildland urban interface it would not qualify for funding under the UBCM SWPI Program. Further details regarding establishment of a fuelbreak on Iron Mountain are provided in the Vegetation Management section of the Action Plan (below).


**Figure 9. North side of the City that requires fuel treatment maintenance (left) and fuel mitigation work (right) to reduce the wildfire risk to the community and developments below.**


**Figure 10. West side of the City that requires fuel mitigation work and establishment of a fuelbreak to reduce the wildfire risk to the adjacent community and new development.**

A summary of the potential treatment areas and recommended treatment types are provided below (Section 8.4).

The MFLNRO fire reporting system was used to compile a database of fires that occurred within the study area. This database provides an indication of fire history but should not be considered comprehensive. The point locations of fires are also approximate as they are based upon a grid system, not the actual location of the fire. Map 8 illustrates ignition locations of historic wildfire between 1950 and 2014. Most ignition points are attributed to human causes with a lower number of ignitions attributed to lightning. Considering the high number of human ignitions compared to lightning caused ignitions (see Map 8), the importance of fire education and regulation is emphasized in the recommendations (Action Plan).




**Map 8. Historic ignitions.**

## 6.3 PRINCIPLES OF FUEL MANAGEMENT

Fuel or vegetation management is a key element of the FireSmart approach. Given public concerns, fuel management is often difficult to implement and must be carefully rationalized in an open and transparent process. Vegetation management should be strategically focused on minimizing impact while maximizing value to the community. The decision whether or not to implement vegetation management must be evaluated against other elements of wildfire risk reduction to determine the best avenue for risk reduction. The effectiveness of fuel treatments is dependent on the extent to which hazardous fuels are modified or removed and the treatment area size and location (strategic placement considers the proximity to values at risk, topographic features, existing fuel types, etc) in addition to other, site specific considerations. The longevity of fuels treatments varies by the methods used and site productivity.

### What is fuel management?

Fuel management is the planned manipulation and/or reduction of living and dead forest fuels for land management objectives (*e.g.*, hazard reduction). Fuels can be effectively manipulated to reduce fire hazard by mechanical means, such as tree removal or modification, or abiotic means, such as prescribed fire. The goal of fuel management is to lessen potential fire behavior proactively, thereby increasing the probability of successful containment and minimizing adverse impacts to values at risk. More specifically, the goal is to decrease the rate of fire spread, and in turn reduce fire size and intensity, as well as crowning and spotting potential (Alexander, 2003).

### Fire Triangle:

Fire is a chemical reaction that requires fuel (carbon), oxygen and heat. These three components make up the fire triangle and if one is not present, a fire will not burn. Fuel is generally available in adequate quantities in the forest. Fuel comes from living or dead plant materials (organic matter). Trees and branches lying on the ground are a major source of fuel in a forest. Such fuel can accumulate gradually as trees in the stand die. Fuel can also build up in large amounts after catastrophic events such as insect infestations. Oxygen is present in the air. As oxygen is used up by fire it is replenished quickly by wind. Heat is needed to start and maintain a fire. Heat can be supplied by nature through lightning or people can be a source through misuse of matches, campfires, trash fires and cigarettes. Once a fire has started, it provides its own heat source as it spreads through a fuel bed capable of supporting it.


### Forest Fuels:

The amount of fuel available to burn on any site is a function of biomass production and decomposition. Many of the forest ecosystems within BC have the potential to produce large amounts of vegetation biomass. Variation in the amount of biomass produced is typically a function of site productivity and climate. The disposition or removal of vegetation biomass is a function of decomposition. Decomposition is regulated by temperature and moisture. In wet maritime coastal climates, the rates of decomposition are relatively high when compared with drier cooler continental climates of the interior. Rates of decomposition can be accelerated naturally by fire and/or anthropogenic means.

A hazardous fuel type can be defined by high surface fuel loadings, high proportions of fine fuels (<1 cm) relative to larger size classes, high fuel continuity between the ground surface and overstorey tree canopies, and high stand densities. A fuel complex is defined by any combination of these attributes at the stand level and may include groupings of stands.

### Surface Fuels:

Surface fuels consist of forest floor, understorey vegetation (grasses, herbs and shrubs, and small trees), and coarse woody debris that are in contact with the forest floor. Forest fuel loading is a function of natural disturbance, tree mortality and/or human related disturbance. Surface fuels typically include all combustible material lying on or immediately above the ground. Often roots and organic soils have the potential to be consumed by fire and are included in the surface fuel category.

Surface fuels that are less than 7 cm in diameter contribute to surface fire spread; these fuels often dry quickly and are ignited more easily than larger diameter fuels. Therefore, this category of fuel is the most important when considering a fuel reduction treatment. Larger surface fuels greater than 7 cm are important in the contribution to sustained burning conditions, but, when compared with smaller size classes, are often not as contiguous and are less flammable because of delayed drying and high moisture content. In some cases, where these larger size classes form a contiguous surface layer, such as following a windthrow event or wildfire, they can contribute an enormous amount of fuel, which will increase fire severity and the potential for fire damage.

### Aerial Fuels:

Aerial fuels include all dead and living material that is not in direct contact with the forest floor surface. The fire potential of these fuels is dependent on type, size, moisture content, and overall vertical continuity. Dead branches and bark on trees and snags (dead standing trees) are important aerial fuels. Concentrations of dead branches and foliage increase the aerial fuel bulk density and enable fire to move from tree to tree. The exception is for deciduous trees where the live leaves will not normally carry fire. Numerous species of moss, lichens, and plants hanging on trees are light and easily ignited aerial fuels. All of the fuels above the ground surface and below the upper forest canopy are described as ladder fuels.

Two measures that describe crown fire potential of aerial fuels are the height to live crown and crown closure (Figure 11 and Figure 12). The height to live crown describes fuel continuity between the ground surface and the lower limit of the upper tree canopy. Crown closure describes the inter-tree crown continuity and reflects how easily fire can be propagated from tree to tree. In addition to crown closure, tree density is an important measure of the distribution of aerial fuels and has significant influence on the overall crown and surface fire conditions (Figure 13). Higher stand density is associated with lower inter tree spacing, which increases overall crown continuity. While high density stands may increase the potential for fire spread in the upper canopy, a combination of high crown closure and high stand density usually results in a reduction in light levels associated with these stand types. Reduced light levels accelerate self-tree pruning, inhibit the growth of lower branches, and decrease the cover and biomass of understory vegetation.

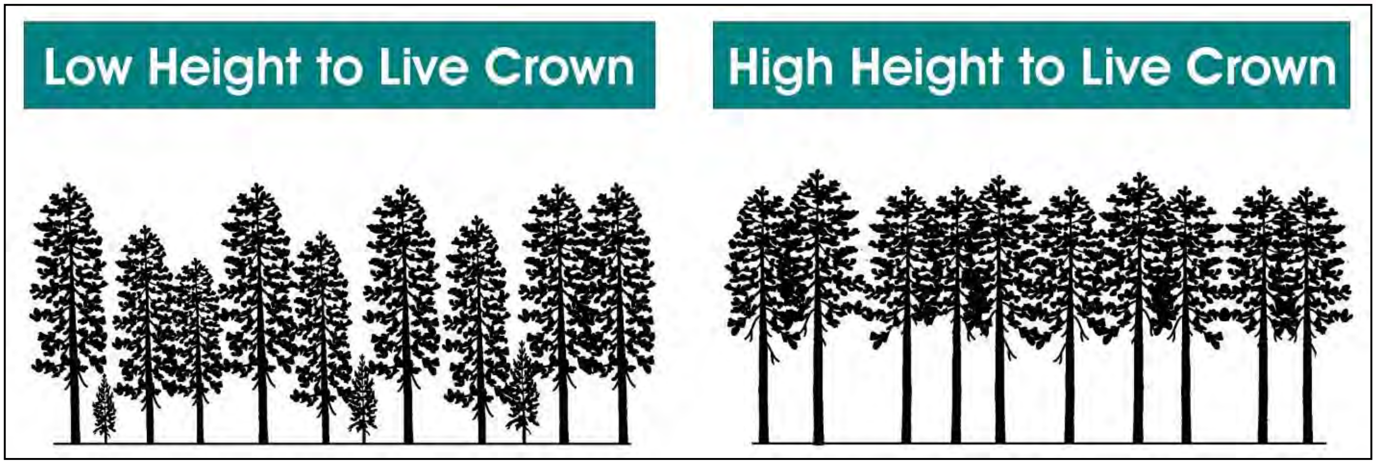



Figure 11. Comparison of stand level differences in height-to-live crown in an interior forest, where low height to live crown is more hazardous than high height to live crown.

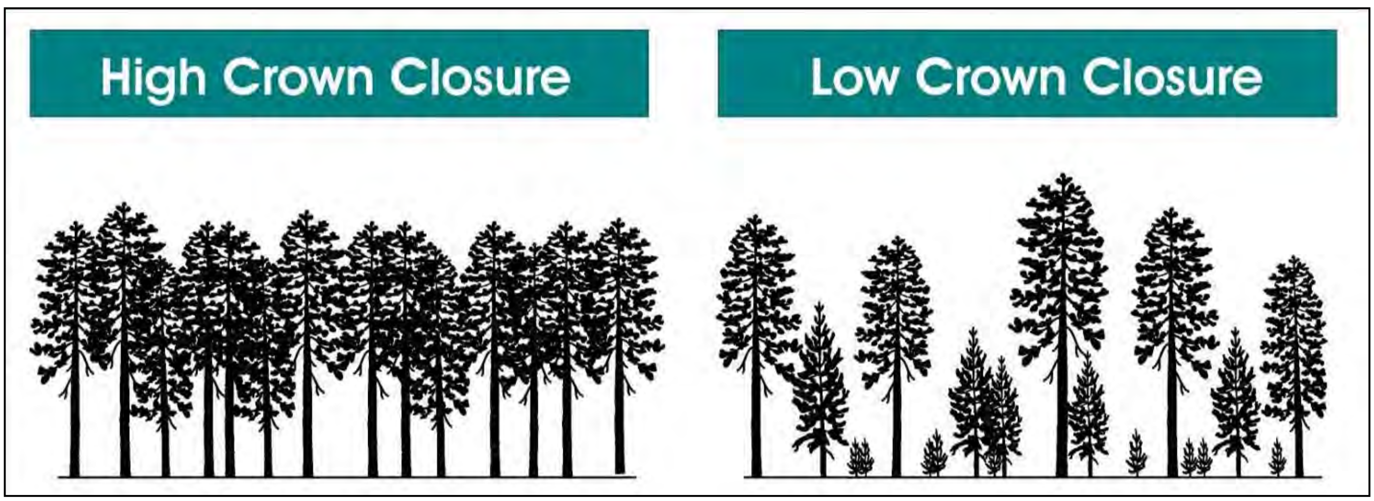



Figure 12. Comparison of stand level differences in crown closure, where high crown closure/continuity contributes to crown fire spread, while low crown closure reduces crown fire potential.

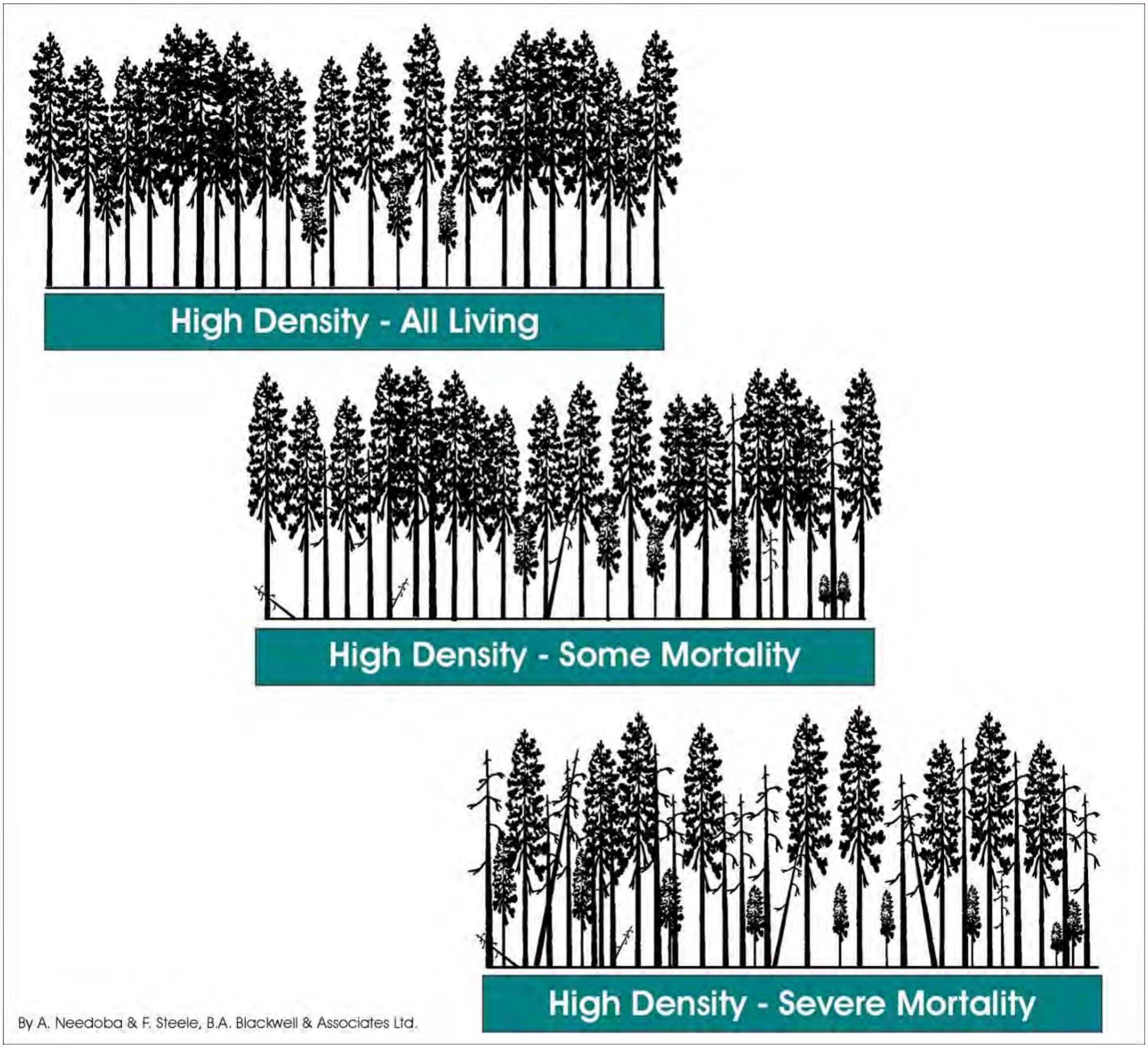



**Figure 13. Comparison of stand level differences in density and mortality, and the distribution of live and dead fuels in these types of stands.**

Thinning is a preferred approach to fuel treatment (Figure 14.) and offers several advantages compared to other methods:

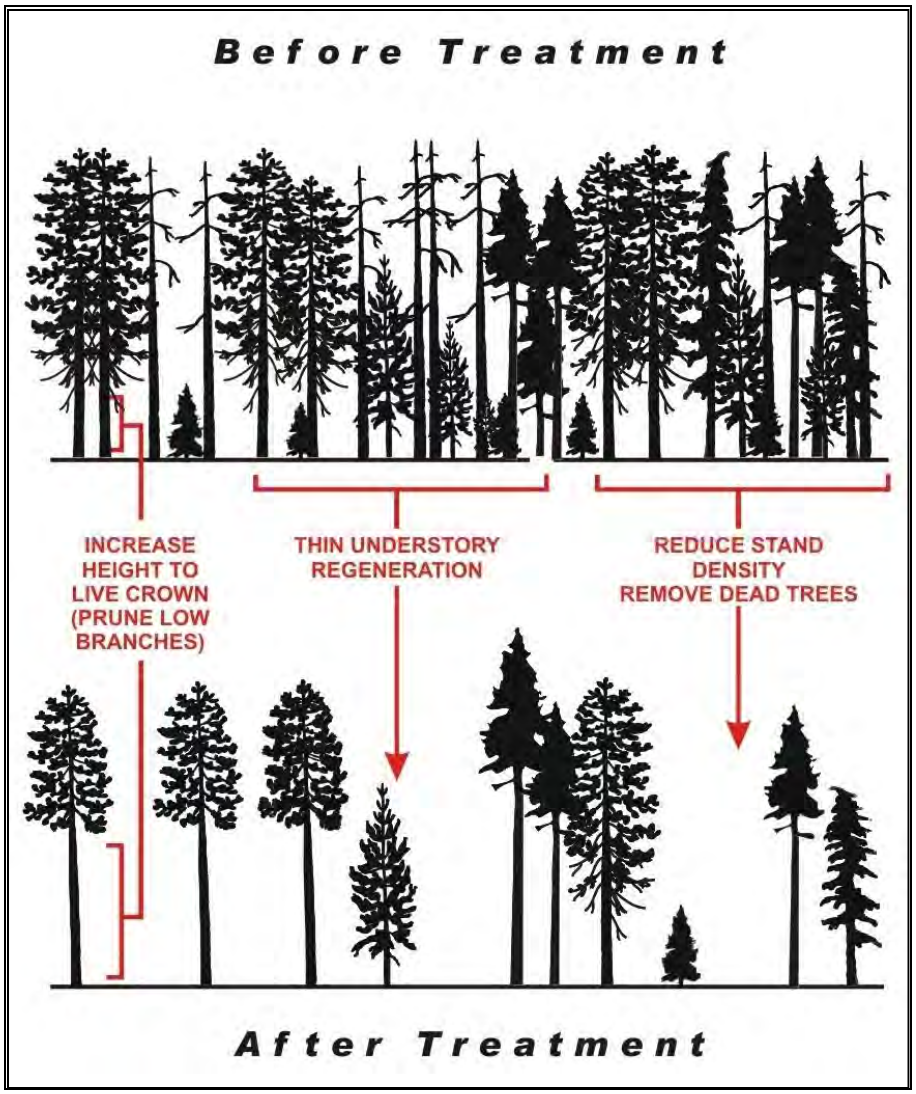
- Thinning provides the most control over stand level attributes such as species composition, vertical structure, tree density, and spatial pattern, as well as the retention of snags and coarse woody debris for maintenance of wildlife habitat and biodiversity.
- Unlike prescribed fire treatments, thinning is comparatively low risk, and is less constrained by fire weather windows.

- Thinning may provide marketable materials that can be utilized by the local economy.
- Thinning can be carried out using sensitive methods that limit soil disturbance, minimize damage to leave trees, and provide benefits to other values such as wildlife.

The main wildfire objective of thinning is to shift stands from having a high crown fire potential to having a low surface fire potential. In general, the goals of thinning are to:

- Reduce stem density below a critical threshold to minimize the potential for crown fire spread;
- Prune to increase the height to live crown to reduce the potential of surface fire spreading into tree crowns; and
- Remove slash created by spacing and pruning to minimize surface fuel loadings while still maintaining adequate woody debris to maintain ecosystem function.

**Figure 14. Illustration of the principles of thinning to reduce the stand level wildfire hazard.**



Fuel type, weather and topography are all primary factors that influence the spread of fires. The three most important components of weather include wind, temperature and humidity. Topography is differentiated by slope, aspect and terrain. Extending beyond the east side of Highway 5 (south of the City boundary) and north of the City there are forested areas with steep slopes which can have a significant influence on fire behaviour. Fuel type and slope are primary concerns related to fire spread along the forested areas on the slope surrounding the City. The steepness of a slope can affect the rate and direction a fire spreads and generally fires move faster uphill than downhill, and fire will move faster on steeper slopes. This is attributed to (MFLNRO, 2014):

- *On the uphill side, the flames are closer to the fuel;*
- *The fuels become drier and ignite more quickly than if on level ground;*
- *Wind currents are normally uphill and this tends to push heat flames into new fuels;*
- *Convected heat rises along the slope causing a draft which further increases the rate of spread; and*
- *Burning embers and chunks of fuel may roll downhill into unburned fuels, increasing spread and starting new fires.*

## 6.4 PRINCIPLES OF LANDSCAPE FUELBREAK DESIGN

Fuelbreaks can be defined as strategically placed strips of low volume fuel where firefighters can make a stand against fire and provide safe access for fire crews in the vicinity of wildfires, commonly for the purpose of lighting backfires. Fuelbreaks act as staging areas where fire suppression crews can anchor their fire suppression efforts; hence increasing the likelihood that fire can be stopped or fire behaviour minimized so the potential for a fire to move fluidly through the interface and into the City would be substantially reduced. The principles of fuelbreak design are described in detail in Appendix B.

It is important to note that fuelbreaks should not be considered stand-alone treatments and other strategies outlined in this plan require equal consideration. To be successful in mitigating wildfire risk, the City needs to integrate the proposed fuelbreak plan with strategic initiatives such as communication and education; structure protection; and enhanced emergency response. Additionally, the implementation of vegetation management on both private and public lands must be considered. An integrated approach to wildfire mitigation will minimize the potential negative social, economic and environmental effects that large catastrophic fires can cause.

# 7.0 COMMUNITY WILDFIRE RISK PROFILE

A Wildfire Risk Management System (WRMS) was used to determine the wildfire risk profile of the study area and aimed at determining the necessary level of planning, preparedness and vegetation condition as it relates to wildfire in the City. The WRMS is based on a spatial model developed in a Geographic Information System (GIS) format using ArcMap 10.1 and ArcInfo 10.1 (ESRI).

The methodology used to develop the WRMS built on the wildfire threat analysis methodology that was initially pioneered in Australia (Muller, 1993; Vodopier and Haswell, 1995) and has since been adapted for use in BC in a number of different contexts and scales (Hawkes and Beck, 1997; Blackwell *et al.*, 2003). In older applications, all fire related factors were rated equally. The WRMS developed by Blackwell and implemented for this project adopts a risk management approach to guide the quantification of separate and discrete landscape-level probability and consequence ratings. This model used a raster grid of 15 m by 15 m resolution. Individual polygons are weighted for each subcomponent. Using algorithms, the subcomponents are combined to produce component weightings which are then further processed to derive probability and consequence ratings. The component weightings are standard values that have been tested and generally used when applying this model.

The content, ratings and weightings for the probability and consequence themes were developed based on professional judgment and experience from past modeling projects with similar parameters. Additionally, the project needs and values at risk relevant to the study area were reviewed prior to model implementation. Details of the component and subcomponent weightings are outlined below.

**Table 3. WRMS component and sub-component weightings and the data sources used to derive each.**

| Probability Rating | | Attribute Weight | Component Weight |
|---|---|---|---|
| **Probability of Ignition** | Lightning Caused Fires | 30% | |
| | Human Caused Fires | 30% | |
| | Ignition Potential | 40% | |
| | | | 30% |
| **Potential Fire Behaviour** | Fire Intensity | 50% | |
| | Rate of Spread | 25% | |
| | Crown Fraction Burned | 25% | |
| | | | 30% |
| **Suppression Capability** | Constraints to Detection | 10% | |
| | Proximity to Water Sources | 10% | |
| | Helicopter Arrival Time | 20% | |
| | Air Tanker Arrival Time | 20% | |
| | Terrain Steepness | 30% | |
| | Proximity to Roads | 10% | |
| | | | 40% |
| | | | **100%** |

| Consequence Rating | | Attribute Weight | Component Weight |
|---|---|---|---|
| **Urban Interface** | Interface | 70% | |
| | Infrustructure | 30% | |
| | | | 50% |
| **Air Quality** | Proximity to Population Centres | 30% | |
| | Smoke Production Potential | 20% | |
| | Smoke Venting Potential | 30% | |
| | Monthly Smoke Venting Potential | 20% | |
| | | | 15% |
| **Water Quality** | Community watersheds and water intakes | 100% | |
| | | | 20% |
| **Ecosystem Integrity** | Red and Blue Listed Elements | 60% | |
| | Old Forest | 10% | |
| | Identified wildlife habitats | 30% | |
| | | | 15% |
| | | | **100%** |

The final spatial probability rating was derived using three major components: *Probability of Ignition, Potential Fire Behaviour* and *Suppression Capability*.

- The I*gnition* component provides a rating of the probability of wildfire occurring in a given location based on historical fire frequency. The rating was calculated as a weighted sum rating using the *Lightning Caused Fires*, *Human Caused Fires* and *Ignition Potential* subcomponents.
- The *Fire Behaviour* component provides a rating of the probability of a wildfire exhibiting extreme fire behaviour in a given location, given existing fuel types and 90$^{th}$ percentile weather conditions. The rating was calculated as a weighted sum rating using the *Fire Intensity, Rate of Spread* and *Crown Fraction Burned* subcomponents that are output from the FBP system.
- The *Suppression Capability* component provides a rating of the probability that a wildfire could be quickly exterminated in a given location, given existing resources. The rating was calculated as a weighted sum rating using *Constraints to Detection, Proximity to Water Sources, Air Tanker Arrival Time, Helicopter Arrival Time, Terrain Steepness* and *Proximity to Roads* subcomponents.

The final spatial consequence rating was derived from four major components that were significant within the study area: *Urban Interface, Air Quality, Water Quality and Ecosystem Integrity.*

- The *Urban Interface* component provides a rating of the potential for a fire to pose a direct threat to people and property. The rating is calculated as a weighted sum rating using *Interface Density* and *Infrastructure* subcomponents.
- The *Air Quality* component provides a rating of the impact that a fire would have on regular air quality within the airshed. The impact is calculated as a weighted sum rating using *Proximity to Population Centers, Smoke Production Potential, Smoke Venting Potential,* and *Monthly Smoke Venting Potential* subcomponents.
- The *Water Quality* component provides a rating of the impact that a fire would have on water and watersheds. The impact is calculated as a weighted sum rating using *Community Watersheds and Water Intakes* subcomponents.
- The *Ecosystem Integrity* component provides a rating of the potential for a fire to pose a direct risk to valued ecosystem resources in the study area. The impact is calculated as a weighted sum rating using *Red and Blue Listed Elements*, *Old Forest* and *Identified Wildlife Habitat* subcomponents.

At the subcomponent level, individual ratings for each raster cell were developed on a 0 – 10 scale based on existing biophysical databases (*e.g*. Vegetation Resource Inventory), professional judgment, and through the application of sub-models (*e.g*. rate of fire spread calculated using the Canadian Fire Behaviour Prediction System).

The WRMS component maps are presented in Appendix A. Fire risk is determined based on a combination of probability and consequence as per the Fire Risk Matrix (Table 4). To determine whether the probability or consequence is low, moderate, high or extreme, the value out of 10 is classified as follows:

- Low: 0 – 2.5
- Moderate: 2.6 – 5.0
- High: 5.1 – 7.5
- Extreme: 7.6 – 10.0

**Table 4. Fire risk matrix (probability X consequence) used to determine risk.**

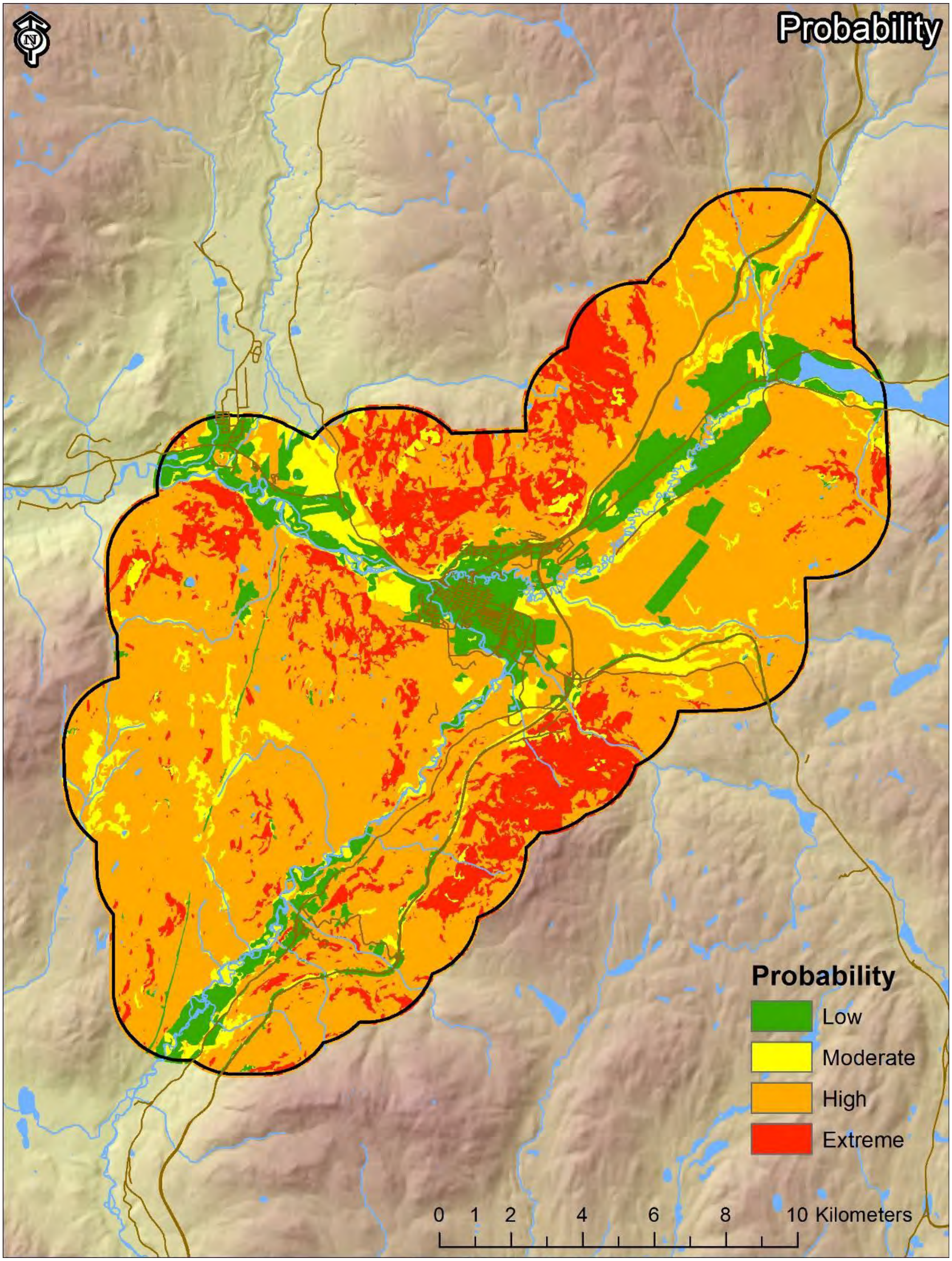
| | | PROBABILITY>>>> | | | |
|---|---|---|---|---|---|
| | | Low | Moderate | High | Extreme |
| <<<<CONSEQUENCE | Low | Low | Low | High | Moderate |
| | Moderate | Low | Moderate | High | High |
| | High | Moderate | High | High | Extreme |
| | Extreme | Moderate | High | Extreme | Extreme |

The WRMS developed in support of this Plan identified that the probability of wildfire within the study area is predominantly high (Map 9). The ignition probability throughout the study area is moderate to high in the developed areas and generally moderate to low throughout the remainder of the study area. Suppression capability is similar and is very good in the developed areas, as expected, and generally moderate to moderately good throughout most of the areas adjacent to the developed areas. There are select isolated areas that have low to moderate suppression response capability due to the location and terrain (isolated, steep slopes).

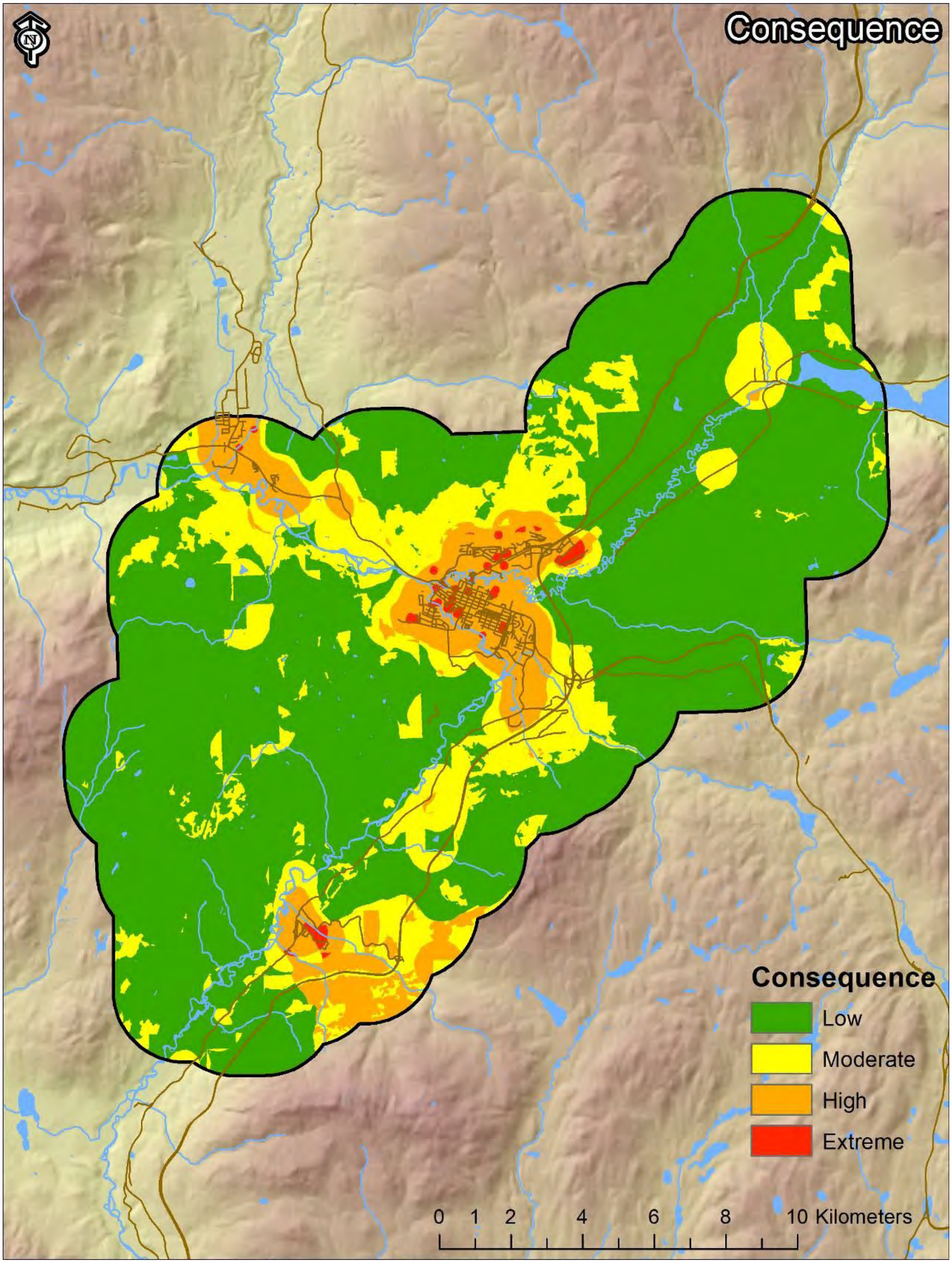
The consequences of a wildfire in the developed areas are high to extreme and this is where interface density is moderate to high. Areas immediately adjacent to the developed areas are moderate and the consequence in the remainder of the study area is generally low (Map 10). Consequence is primarily driven by the urban interface. The subcomponents for air quality, water quality and ecosystem integrity only contribute noticeably to the definition of consequence when they overlap with urban interface values and this is primarily due to their weightings in the model. Any one of the components (other than urban interface) occurring alone with no overlaps is not weighted high enough to increase consequence above low to moderate. This is based on the assumption that any one of these consequence components occurring independently is not a significant driver of risk and does not warrant a risk response.

Probability and consequence are used to calculate the overall wildfire risk (Map 11). Fire risk throughout the developed areas is generally moderate to high with some isolated points that are extreme. The City itself is ranked low and the area immediately adjacent to the City is high. Beyond the developed areas the overall fire risk is generally low. Areas of extreme fire risk are generally limited throughout the study area considering the extreme probability areas do not overlap with areas of high or extreme consequence. This is driven by the values at risk and the fuels that surround them.

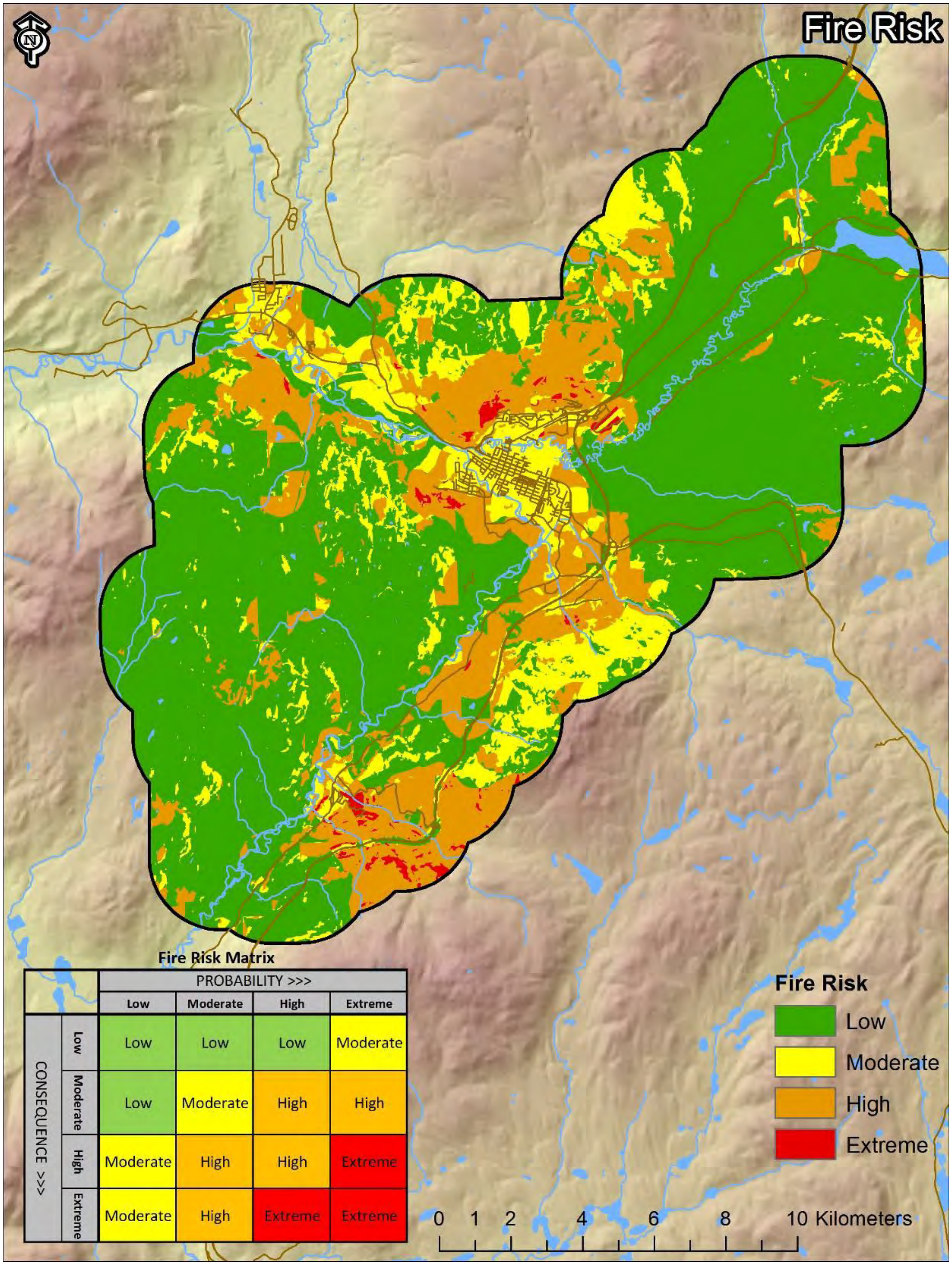
All component maps (with subsets of the subcomponents) are provided in Appendix A.




**Map 9. Probability of wildfire occurring from the Wildfire Risk Management System.**




**Map 10. Consequence ratings according to the Wildfire Risk Management System.**




**Map 11. Overall risk of wildfire occurring the in the study area according to the Wildfire Risk Management System.**

# 8.0 ACTION PLAN

The following material consists of the key elements of the CWPP and provides recommendations to address each element. The elements discussed in this section include: Communication and Education; Structure Protection and Planning; Emergency Response; and Vegetation/Fuel Management.

## 8.1 COMMUNICATION & EDUCATION

Awareness and understanding support the adoption of tools to reduce fire risk, and in communities where the dangers of wildfire are understood there is increased support and interest in reducing fire risk. The establishment of tools to reduce fire risk is one of the keystones to building a FireSmart community. Without the support of the community, the efforts of public officials, fire departments, and others to reduce wildfire will be hindered. In many communities there is generally a lack of understanding about interface fire and the simple steps that can be taken to minimize risk. Additionally, public perception of fire is often underdeveloped due to public confidence and reliance on local and provincial fire rescue services.

Based on the consultation completed during development of this Plan, it is evident the City generally has a good level of awareness of fire risk in the interface; however, field observations highlighted the need to further educate the community on what private land owners can do to build a FireSmart community. The Communication and Education objectives for the study area are:

- To improve public understanding of fire risk and personal responsibility by increasing resident awareness of the wildfire threat in their community and to establish a sense of homeowner responsibility; and
- To enhance the awareness of elected officials and stakeholders regarding the resources required to mitigate fire risk.

The two principal goals for the City to enhance wildfire related Communication and Education should be to:

- Reduce fire ignitions; and
- Reduce fire risk on private property.

Communicating effectively is the key aspect of education. Communication materials must be audience specific, and delivered in a format and through a medium that will reach the target audience. Audiences should include home and land owners, school students, local businesses, council and staff, regional directors and staff, local utilities, and forest tenure holders. Education and communication messages should be simple yet comprehensive. A basic level of background information is required to enable a solid understanding of fire risk issues and the level of complexity and detail of the message should be specific to the target audience.

The City should consider implementing a multi-media education program that maximizes education efforts during the wildfire season. The website could be upgraded to display wildfire prevention information prominently and display fire/burning bans when they are in effect. Websites and social media are some of the most cost-effective methods of communication available. Additionally, wildfire preparedness education could be presented annually in elementary schools and the local fire departments could utilize websites and social media to communicate fire bans, wildfire prevention initiatives and other real time information.

Provincial funding for fuel management is only provided for public lands. It is important for homeowners to understand what they can do to reduce the risk of wildfire damage to their property or adjacent residences. In particular, WUI property owners need to be made aware of their responsibility to implement FireSmart mitigation measures on their properties and also understand how their contributions benefit community wildfire safety.

FireSmart information material is readily available and simple for municipalities to disseminate. It provides concise and easy-to-use guidance that allows homeowners to evaluate their homes and take measures to reduce fire risk. However, the information needs to be supported by locally relevant information that illustrates the vulnerability of individual houses to wildfire.

Bringing organizations together to address wildfire issues that overlap physical, jurisdictional or organizational boundaries is a good way to help develop interagency structures and mechanisms to reduce wildfire risk. Engagement of various stakeholders can help with identifying valuable information about the landscape and also help provide unique and local solutions to reducing wildfire risk. In the past the City was involved with a regional interface committee that is no longer active. The City should try to lead the re-establishment of a regional interface committee to coordinate wildfire risk reduction efforts and aim to integrate forest licensees that are operating within the Merritt TSA. Coordination of fuel management activities with forest licensees could significantly aid in the establishment of large, landscape-level fuel breaks or compliment current or proposed fuel treatment areas.

The City Fire Department did emphasize concerns with internal capacity to enhance wildfire communication and education with the existing resources so it is recommended that the City seek external support for priority activities that cannot be completed with internal resources. This includes utilization of City staff, volunteers or hiring an experienced contractor to support and guide communication and education activities.

**Table 5. Summary of Communication and Education recommendations.**

| Communication and Education | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: To improve public understanding of fire risk and personal responsibility by increasing resident awareness of the wildfire threat in their community and to establish a sense of homeowner responsibility. | | | |
| 1 | High | • Develop a demonstration FireSmart property in a central location in the Regional District to provide homeowners with a working example of what a FireSmart home and property looks like and how it can be achieved. | $3,000 |
| 2 | High | • Upgrade the City and the Merritt Fire Rescue website to display or link wildfire prevention information and display real time information on fire bans and high fire danger, and provide a link to FireSmart information. | Within current operating costs |
| 3 | High | • Utilize social media (*e.g.*, Facebook, Twitter, etc.) to communicate fire bans, high fire danger days, wildfire prevention initiatives and other real time information. | Within current operating costs |
| 4 | High | • Deliver wildfire preparedness education in elementary and high schools. | Within current operating costs |
| 5 | Moderate | • Fire Departments should rate houses on suitability for triage and share rating information and recommendations with homeowners in high hazard areas. | Within current operating costs |
| 6 | Moderate | • Post information from the CWPP on the City website showing areas with hazardous fuel complexes. | Within current operating costs |
| 7 | Low | • Install educational signage in high fire ignition areas. | $5,000 + maintenance |
| 8 | Low | • Encourage more frequent visits by the Fire Department during high and extreme fire danger times to high ignition areas (e.g., homes, parks, trails, *etc*.). | Within current operating costs |
| **Objective:** To enhance the awareness of elected officials and stakeholders regarding the resources required to mitigate fire risk. | | | |
| 9 | Moderate | • Establish a regional interface committee to coordinate wildfire risk reduction efforts and aim to integrate forest licensees that are operating within the Merritt TSA. Coordination of fuel management activities with forest licensees could significantly aid in the establishment of large, landscape-level fuel breaks or compliment current or proposed fuel treatment areas. | Within current operating costs |

## 8.2 STRUCTURE PROTECTION & PLANNING

Establishing a FireSmart community will reduce losses and impacts related to wildfire. For this Plan two classes of structures were considered: critical infrastructure; and residential or commercial infrastructure. Critical infrastructure is distinct as it provides important services that may be required during a wildfire event or may require additional considerations or protection. As outlined above, FireSmart principles are important when reducing wildfire risk to both classes of structure and are reflected in the outlined recommendations. The structure protection objectives for the City are to:

- Enhance protection of critical infrastructure from wildfire; and
- Encourage private homeowners to voluntarily adopt FireSmart principles on their properties.

The two main avenues for implementing FireSmart include:

- Change the vegetation type, density and setback from the structure; and
- Change the structure (where feasible) to reduce vulnerability to fire and reduce the potential for fire to spread to or from a structure.

Critical infrastructure is important to consider when planning for a wildfire event. The use of construction materials, building design and landscaping must be considered for all structures when completing upgrades or establishing new infrastructure. Additionally, vegetation setbacks around critical infrastructure should be compliant with FireSmart recommendations.

Detailed FireSmart assessments were not completed for structures but general observations were made. In general the exteriors of most buildings were constructed of fire resistant material. Vents on some structures may require finer screens to prevent embers from entering the building envelope and should be reviewed. Additionally, not all critical infrastructure have adequate setbacks from vegetation, such as the Iron Mountain communication tower. Furthermore, only one of the five well pumps has a backup generator. All water infrastructure and the communication towers on Iron Mountain were identified by the City Fire Department as vulnerable to lightning strikes. Back-up power sources should be installed for all critical infrastructure to ensure the City can continue to operate at an acceptable level during a wildfire event.

Currently, high hazard fuels located outside the WUI area are not recognized for treatment funding within the current Strategic Wildfire Prevention Initiative (SWPI) UBCM[10] program. Approval typically is only given for areas with a 'high' or 'extreme' WUI Threat Class rating. To achieve these ratings, assessment areas must be within 500m of development. In this case, the Iron Mountain Communication towers are considered critical infrastructure, however are too far from the interface to qualify for funding. Collectively, municipalities and others dependent on this infrastructure need to assess and, where hazards are identified, treat this area to protect the infrastructure to minimize potential for failure during an emergency and/or requirements for recovery post wildfire. Fuel management recommendations for the Iron Mountain Communication towers are further addressed in section 8.4.

[10] http://www.ubcm.ca/EN/main/funding/lgps/strategic-wildfire-prevention/2015-swpi-program.html

Currently the study area includes Wildfire Hazard Development Permit Areas however homes beyond these boundaries, particularly in older subdivisions, need to ensure they consider and adopt FireSmart principles as required and as opportunities arise (*e.g*, exterior home construction). Many of the older homes do not have rated roofs or constructed with fire vulnerable siding and are close to flammable vegetation. Fire research indicates that roofing adjacent to burnable materials and landscaping play the greatest role in structure ignitability. The reduction of wildfire hazards to these vulnerable homes generally depends on the homeowner. This includes choices in exterior building materials, setbacks from forest edges and landscaping. The latter two are great options for existing homes. Developing an example of a FireSmart home and yard within the City boundary could provide homeowners with an example of what a FireSmart property looks like and provide incentive for implementing the principles. Additionally, many homes in interface and intermix areas store combustible materials within 10 m of residences and this is a significant fire issue. Woodpiles or other flammable materials adjacent to homes provides fuel and an ignitable surface for embers, increasing wildfire risk and impacts to the homes and community. The recently launched 2016 SWPI FireSmart Grant Program provides funding of up to $10,000 to undertake FireSmart planning activities for private lands. Funding will be available to local governments and First Nations with the intent to enable communities to take the required actions to achieve and/or maintain a FireSmart community as outlined by FireSmart Partners in Protection.[11]

With UBCM funding, the City could develop a FireSmart program that would include community education and support for implementing FireSmart principles on private land. This could include the planning and implementation of an annual open house where private land owners can obtain FireSmart planning information that is customized to the community. Additionally, the City could consider developing extension materials (pamphlets or booklets) that could be distributed at an open house or public events. Other FireSmart activities could include direct homeowner support. For example, trained City staff could spend a weekend visiting homeowners that have expressed interest in receiving planning support, and staff could use the opportunity to provide advice on how to best approach implementing FireSmart in specific neighbourhoods.

**s not built**
**as a cedar**
**nable**
**zone.**

[11] http://www.ubcm.ca/EN/meta/news/news-archive/2015-archive/new-firesmart-grant-program-launched.html

**Table 6. Summary of Structure Protection and Planning recommendations.**

| Structure Protection and Planning | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: Enhance protection of critical infrastructure from wildfire. | | | |
| 10 | High | • Prioritize upgrades for critical infrastructure to ensure all buildings are to FireSmart standards. | Within current operating costs |
| 11 | High | • Complete a detailed review of back-up power source options for all critical infrastructure and upgrade as required. | Within current operating costs |
| **Objective:** Encourage private homeowners to voluntarily adopt FireSmart principles on their properties | | | |
| 12 | High | • Apply for funding under the 2016 SWPI FireSmart Grant Program to undertake FireSmart planning activities for private lands. | $10,000 (UBCM FireSmart Grant) |
| 13 | High | • Encourage residents to adopt FireSmart principles on their property through communication and education initiates including establishment of a FireSmart home and yard within the City boundary to provide homeowners with an example of what a FireSmart property looks like. | Within Current Operating Costs/One-time additional cost $3000 |

## 8.3 EMERGENCY RESPONSE

Fire departments within the study area (City of Merritt, Coldwater Indian Band and Nicola Indian Band) are responsible for first response within their fire protection area. The Emergency Response objectives for the study area are:

- To improve structural and wildfire equipment and training available to City Fire and Rescue; and
- To enhance communication and cooperation among fire departments.

The majority of training for the City of Merritt Fire and Rescue focuses on structural fire fighting but does include annual cross-training with MFLNRO BCWS. All members at a minimum have S100 training and it is recommended that the Fire Department provide members with S215 training. There is a good line of communication between City Fire and Rescue and the BCWS, and a number of current City Fire and Rescue members were former BCWS crew members. The City and MFLNRO BCWS work closely together to support wildland emergency response throughout the study area however it is recommended that the City coordinate a joint wildfire simulation training event with the BCWS.

For the areas beyond the City's fire protection area there are currently no mutual aid agreements in place. The City has submitted an agreement to the Coldwater Indian Band and it is currently under review. The Lower Nicola Indian

Band has an agreement in place with the TNRD as well as with the City of Merritt. The City has hosted training events and offered seats to local Indian Bands. It has been noted that the Lower Nicola Indian Band and Coldwater Indian Band are being challenged with recruiting new members in small communities.

The greatest challenges facing the City Fire and Rescue are related to equipment and water infrastructure. Currently the City has a well-functioning wildland truck and has a 21 unit sprinkler kit with trained members however, this sprinkler kit was designed for a large municipal setting and there are gaps to utilize this in Merritt's more rural and less densely developed municipal setting. Although the City of Merritt is serviced by hydrants, there are challenges with water supply beyond the City boundary and it is recommended that the City consider investing in their own water trailer/water truck and a 30 unit sprinkler kit to enhance their response capabilities without depending on a third party. To ensure competent wildland fire response capabilities, the City Fire Department should complete a review of wildland equipment and document any deficiencies. Additionally, the Fire Department should be supported in the acquisition of any required wildland equipment. Specifically, it is recommended that the City of Merritt explore a partnership with the TNRD to assess the need for and fund the purchase of a water tender with an Underwriters Laboratory rated pumping capacity to support emergency response in Fire Protection Agreement areas which border the City. These bordering areas are challenging to service as water supplies are either scarce or non-existent. Furthermore, the acquisition of a water tender/tanker would ensure that the City's pumping capacity within the City boundary would not be compromised when fire apparatus is used to action fires outside the City of Merritt boundary.

Access throughout the study area is variable however most areas within the City boundary have multiple access routes with the capacity for emergency vehicle access. Identified areas of concern include the Bench, Belshaw and Eagle developments. These areas should be reviewed for alternate access and egress options. Emergency access and evacuation planning has not been formalized throughout the study area and it is something the City should review with the support of the local RCMP detachment to enhance safety for the areas of concern. Additionally, emergency access and evacuation planning is of particular importance in the event of a wildfire event but is also important during large public events such as several annual music festivals. An evacuation plan could:

- Map and identify safe zones, marshalling points and aerial evacuation locations;
- Plan traffic control and accident management;
- Identify volunteers that can assist during and/or after evacuation;
- Create an education/communication strategy to deliver emergency evacuation procedures to residents.

Many homes lack visible addresses and could benefit from triage assessments to ensure accessibility and safety for firefighters. Fire triage is an important tool used by fire suppression crews to improve the potential for structures to survive a fire event. The process involves determining which houses have the greatest likelihood of surviving a wildfire and therefore should be prioritized for additional protective measures such as setting sprinklers or spraying retardant. Triage assessments are dependent on five main factors which include: firefighter safety, structure design and material, fuels around the structure, fire behavior, and available resources. Houses that follow FireSmart guidelines have a better probability of being prioritized for protection. Conducting assessments of housing in the WUI prior to a fire can assist in suppression efforts. The assessments can also be used to educate homeowners as to what protection they might receive during a fire event and what changes they can make to improve the probability of their home surviving a fire event.

**Table 7. Summary of Emergency Response recommendations.**

| Emergency Response | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: To improve structural and wildfire equipment and training available to City Fire and Rescue. | | | |
| 14 | High | • Complete the acquisition of the proposed pumper tanker for the City Fire Department. | Within current annual operating costs |
| 15 | High | • In partnership with the TNRD, assess the need for and fund the purchase of a water tender with an Underwriters Laboratory rated pumping capacity to support emergency response in Fire Protection Agreement areas which border the City. | $400,000 (one time cost) |
| 16 | High | • Support the acquisition of a Sprinkler Trailer resource and provide sprinkler deployment training for all department members. The kit should be able to protect up to 30 rural widely spaced interface homes. | $40,000 (one time cost) |
| 17 | High | • Maintain current structural and interface training with all Fire Departments and MFLNRO BCWS, and conduct annual reviews to ensure PPE and wildland equipment resources are complete. Interface training should include completion of a mock wildfire simulation in coordination with BCWS. | Within current annual operating costs |
| 18 | Moderate | • Provide S215 training to all/some members of the City Fire Department to enhance wildfire suppression training. | $2,000? (annually) |
| 19 | Moderate | • The City should consider developing an Evacuation Plan in coordination with the local RCMP detachment to: map and identify safe zones; marshalling points and aerial evacuation locations; plan traffic control and accident management; identify volunteers that can assist during and/or after evacuation; and create an education/communication strategy to deliver the information. | $7,000 + maintenance |
| 20 | Low | • Support on-call staff recruitment and training for the Lower Nicola Indian Band and Coldwater Indian Band. | Within current annual operating costs |
| **Objective:** To enhance communication and cooperation among fire departments. | | | |
| 21 | High | • Encourage homeowners to post house numbers in a manner that makes them clearly visible to aid emergency response. | Within current annual operating costs |
| 22 | Moderate | • Complete fire triage of homes in the WUI to improve the potential for structures to survive an event by educating homeowners of the improvements they can make. | Within current annual operating costs |

## 8.4 FUEL MANAGEMENT

Fuel management (also referred to as vegetation management or fuel treatment) is generally considered a key element of a FireSmart approach. The City has completed various fuel management activities within and adjacent to the City (within the study area). To compliment the work completed to-date and to further reduce the wildfire risk in the study area, the objectives for fuel management are to:

- Reduce wildfire threat on private and public lands through fuel management;
- Establish landscape-level fuelbreaks to enhance community protection.

These objectives will enhance protection to homes and critical infrastructure by proactively reducing fire behaviour.

As discussed above, fuel treatments are designed to reduce the possibility of uncontrollable crown fire through the reduction of surface fuels, ladder fuels and crown fuels. This threshold of reduction varies by ecosystem type, current fuel type, fire weather, slope and other variables. Additionally, fuel management can be an effective method of reducing fire behaviour; however it is important to note that it does not stop wildfire. The purpose of altering vegetation for fire protection must be evaluated against the other key CWPP elements (outlined above) to determine its necessity.

Fuel management can be undertaken with minimal negative or even positive impact on the aesthetic or ecological quality of the surrounding forest and does not mean removing most of the trees. The focus for fuel management in the interface is not necessarily to stop fire but to ensure that fire severity is low enough that fire damage is limited. For example, treating around a home may prevent structure ignition due to direct flame contact and then the ability of the home to survive the fire would come down to whether construction materials can survive ember attack. The intent of fuel management is not to stop the fire but to reduce fire severity.

One of the constraints with fuel management is private land as funds from public sources such as UBCM are only for Crown lands and as noted above cannot be used to treat private or First Nations lands. The best approach to mitigate fuels on private lands is to promote FireSmart (as described under Structure Protection and Planning). A FireSmart approach to fuel management within 100 m of structures is considered beneficial in order to improve defensible space around structures and to reduce the likelihood that a house fire could spread to adjacent forests. In general, when considering fuel management to reduce fire risk, the following steps should be followed:

- A qualified professional forester must develop the prescriptions;
- Public consultation should be conducted during the process to ensure community support;
- Treatment implementation must weigh the most financially and ecologically beneficial methods of fulfilling the prescriptions goals;
- Pre- and post-treatment plots should be established to monitor treatment effectiveness; and
- A long-term maintenance program should be in place or developed to ensure that the fuel treatment is maintained in a functional state.

Based on recommendations from the original CWPP that was completed in 2006, fuel treatments activities were completed within the study area and included specific mountain pine beetle fuel reduction targets. Mountain pine beetle activity in the area has declined resulting in reduced mountain pine beetle killed trees however spot infestations are still visible throughout the study area in addition to tree mortality related to Douglas-fir bark beetle, balsam bark beetle and spruce beetle. Bark beetle killed trees do not significantly increase the wildfire hazard or existing fuel types in the study area. It is important to note the observed conditions do not account for forest health conditions beyond the study boundary. Additionally, beetle killed trees are present in the select priority treatments of this Plan.

To assess risk, the *Provincial WUI Wildfire Threat Rating Worksheets* (worksheet) were used, as required by UBCM[12], in addition to professional judgment (WUI summaries are provided as a separate document). The worksheet provides point ratings for four components that contribute to wildfire risk. These components include fuels, weather, topography and structural values at risk. Proposed projects to reduce the wildfire hazard to the study area are summarized in Table 8 and Table 9 and locations are illustrated in Figure 16.

Three proposed fuel treatment maintenance polygons are located north of the City (Peregrine Way, Allen Road A and B, and Pineridge Drive) as indicated in Figure 17. Recommended treatment types are maintenance activities that include reduction of surface fuels and pruning in one polygon. Additionally, it has been recommended that an effort to reduce the presence/establishment of invasive species be considered in all fuel management activities. Fuel management for these outlined areas are eligible for UBCM funding. In the future, maintenance burns using prescribed broadcast burning are recommended every five to seven years as a preferred option to maintain previously thinned treatment areas. This method is less expensive and onerous for the City and should be conducted by trained staff in coordination with BCWS or with the assistance of the BCWS.

A small section of grass adjacent to the Central Park Walking Trail was identified as a hazard to the homes located above the Park. It is recommended that a 3 m fuel-free buffer is established adjacent to the trail. This will limit the probability of a grass fire moving from the trail to the homes above as a result of a tossed cigarette butt or a spark from a mower. Considering this area does not qualify for UBCM funding, it is recommended that the City work with local businesses or the local Rotary Club to support vegetation management activities. Alternatively, the City may incorporate mitigation into the City's existing Public Works Parks program including mowing (at a minimum).

In addition to the previously treated polygons, along the northern boundary of the municipality, we recommend that areas adjacent to the airport and the Central Park Walking Trail be given priority for ongoing grass and sage fuels treatment and maintenance. These areas represent a rapid spread risk in close proximity to homes and critical infrastructure. The Merritt airport also does not meet the WUI threat rating to qualify for UBCM funding. It is recommended that the City coordinate with BCWS Merritt Fire Zone to conduct prescribed broadcast burning on an as-needed basis, subject to BWS crew availability in the area as identified in Figure 17.

[12] http://www.ubcm.ca/assets/Funding~Programs/LGPS/Current~LGPS~Programs/SWPI/Resources/swpi-WUI-WTA-Guide-(2012-Update).pdf

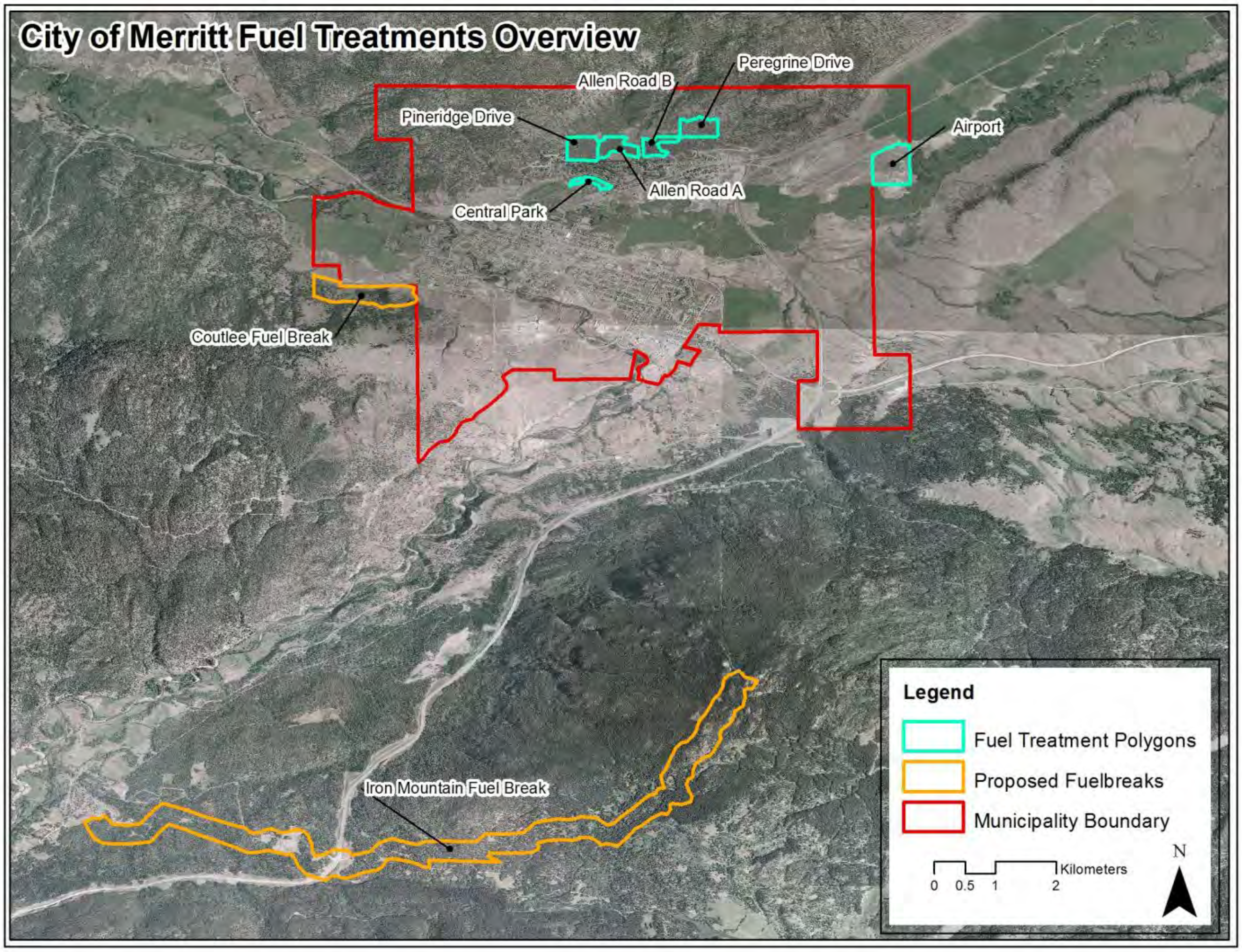



**Figure 16. Overview map of fuel management treatment areas.**

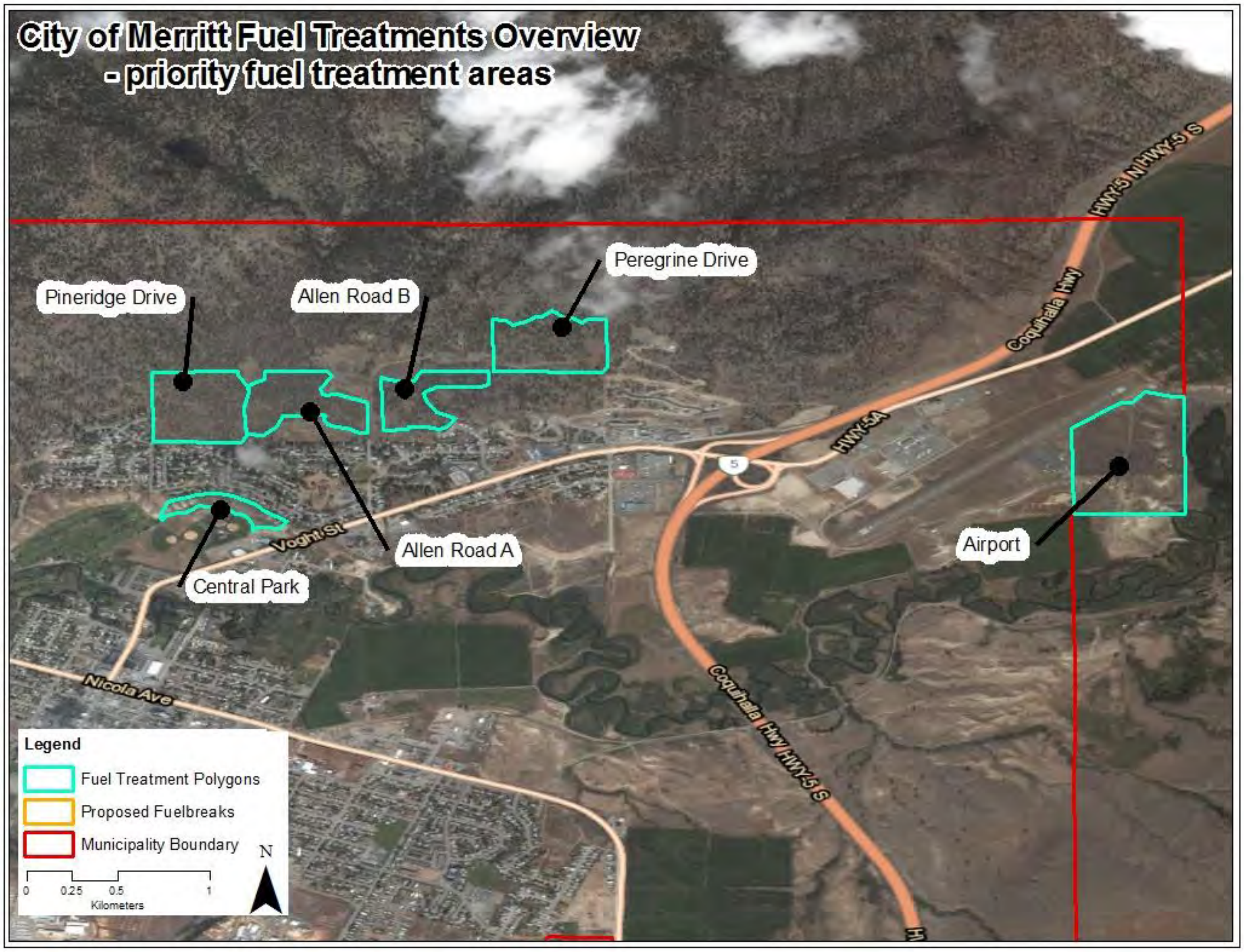



**Figure 17. Location of proposed fuel treatment areas.**

The City should apply for Strategic Wildfire Prevention Initiative UBCM[13] funding to complete the outlined fuel treatment activities of the priority treatment areas along the north side of the City. Establishment of a fuel-free zone along the Central Park Walking Trail could be subsidized through local support and should be coordinated by the City and Fire Department. It is also recommended that the City utilize the BCWS Merritt Fire Zone Office and Provincial Training Centre that is located in the City and work with the BCWS to incorporate training of BCWS members into implementing fuel management activities in the identified fuel treatment areas. This would be a great opportunity for BCWS members to enhance their skills and training using various tools and would benefit the City in tackling the required fuel treatments.

The establishment of two landscape-level fuelbreaks is proposed for the west side of the City (Coutlee) and along Iron Mountain which is located on the south side of Highway 1. These breaks are proposed to reduce the likelihood of a wildfire moving from the west into the Coutlee bench or moving in from the southwest over Iron Mountain and

[13] http://www.ubcm.ca/EN/main/funding/lgps/current-lgps-programs/strategic-wildfire-prevention/2014-swpi-program.html

do not currently qualify for UBCM funding under the current program. Existing physical features were considered in establishing fuelbreak positions and the exact areas will need to be confirmed in the field/during prescription development. The development of these fuelbreaks will require the support and coordination of the MFLNRO and licensees that are operating in the area. Additionally, the City should try to utilize BCWS wildfire suppression crews to assist with fuelbreak establishment as opportunities arise.

Sketched locations for fuelbreaks on the Coutlee Bench and Iron Mountain are illustrated in the figures below (Figure 18 and Figure 19). Fuelbreak locations were determined based on professional judgment, consideration of existing physical features and visual observations during a field reconnaissance.

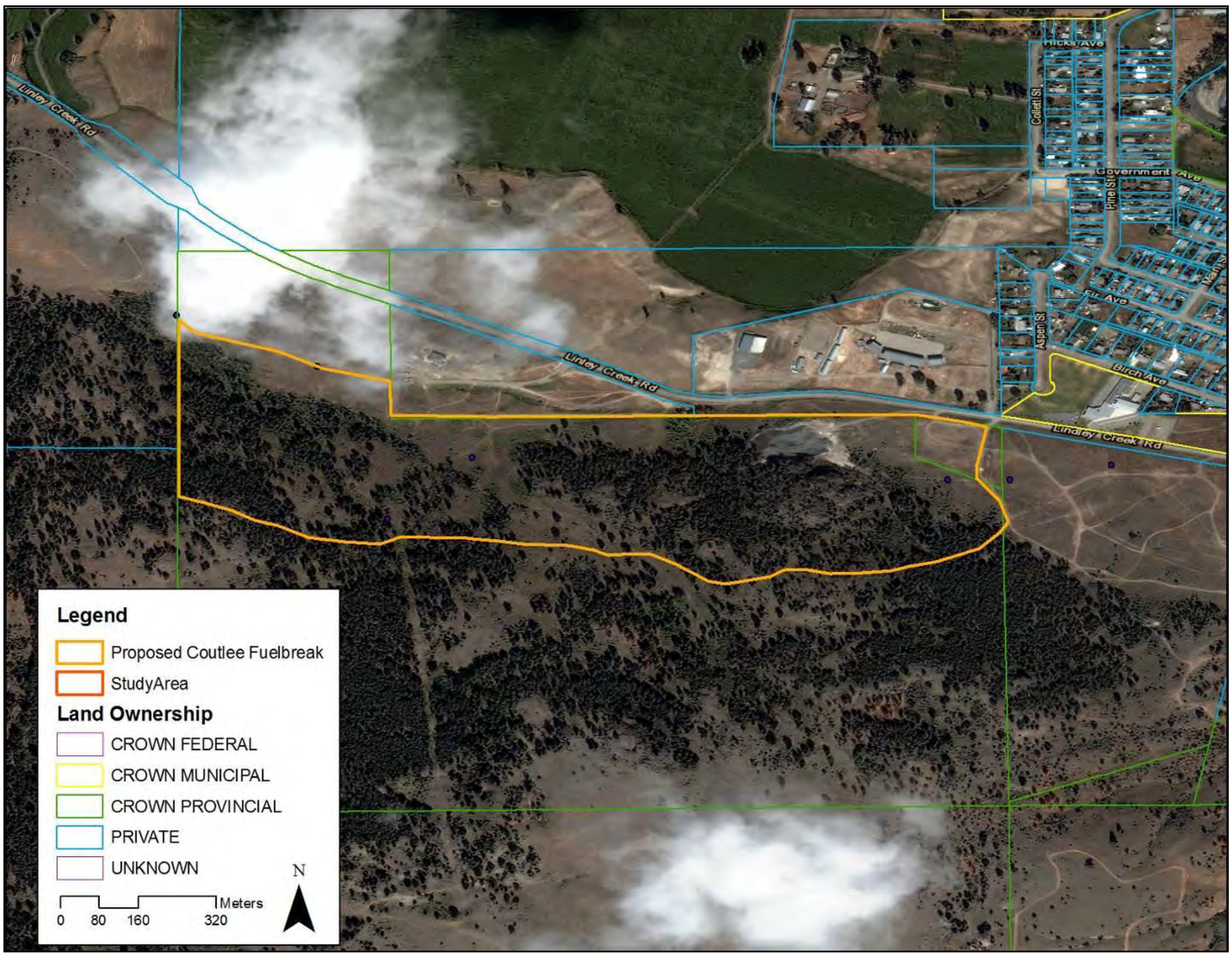



**Figure 18. Proposed location for a fuelbreak of approximately 250 m wide along the Coutlee Bench.**

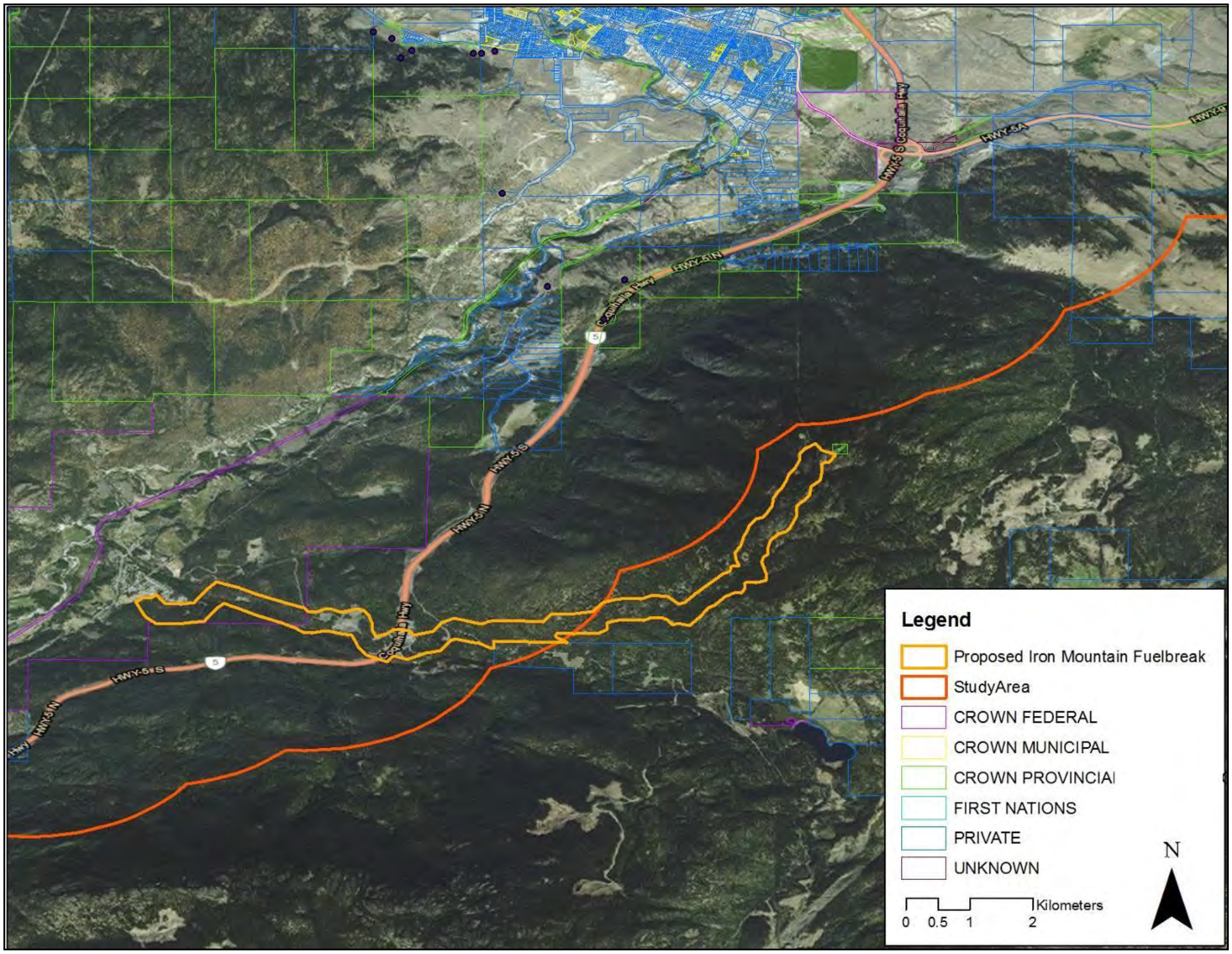



**Figure 19. Proposed location for a fuelbreak of approximately 300 m wide along south side of Highway 5, on Iron Mountain.**

**Table 8. Priority fuel treatment areas.**

| Treatment Polygon | WUI Threat Plot | Priority | Fuel Type | Approximate Area (ha) | Recommended Treatment Type | Comments |
|---|---|---|---|---|---|---|
| **Fuel Treatments** | | | | | | |
| Peregrine Way | 1 | 1 | C7 | 11 | Maintenance:<br>• Prune pine trees up to 2 m; and<br>• Burn surface grass cover (40-60% coverage) every 5-7 years.<br>• Reduce presence/establishment of invasive species. | Polygon is on provincial land and located on a northwest slope of a new development. The new development is located mid-slope on the north side of the City (northwest of Peregrine Way). Complete maintenance to reduce rapidly spreading surface fires and surface fires moving into tree crowns. |
| Allen Road A and B | 2 | 1 | C3/C7 | 10 (A) + 7 (B) | Maintenance:<br>• Burn surface grass cover (40 – 60% coverage) every 5-7 years.<br>• Treat above and below road.<br>• Reduce presence/establishment of invasive species. | Polygon is within a previously treated area and is located on a northwest slope, north of the City and northeast and northwest off Allen Road. The Nicola Valley Hospital and Health Center is located south of this proposed treatment unit. Complete maintenance to reduce rapidly spreading surface fires. |
| Pineridge Drive | 3 | 2 | C7 | 12 | Maintenance:<br>• Prune pine trees up to 2 m; and<br>• Burn surface grass cover (40-60% coverage) every 5-7 years.<br>• Reduce presence/establishment of invasive species. | Polygon is on provincial land and located on a north facing slope, north/northeast of Pineridge Drive. Complete maintenance to reduce rapidly spreading surface fires and surface fires moving into tree crowns. |

| Treatment Polygon | WUI Threat Plot | Priority | Fuel Type | Approximate Area (ha) | Recommended Treatment Type | Comments |
|---|---|---|---|---|---|---|
| **Fuel Treatments** | | | | | | |
| Central Park | 4, 5 | 1 | O1b | 3 | Surface fuel management:<br>• Create a 3 m fuel-free zone immediately adjacent to the north side of the Central Park Walking Trail by removing the grass and/or replacing with a hard surface (preferably a permeable surface) or replace with non-flammable vegetation.<br>• Treatment should extend to the Merritt Golf and Country Club. | Polygon is on municipal land and located immediately adjacent to the Central Park Walking Trail and on the bottom of a small slope that is lined with homes. A fuel-free zone will reduce the probability of a surface fire traveling up the slope and into the homes along Parker Drive. |
| Iron Mountain Communication Towers | NA | 1 | C7/C3 | 6 | Overstory/Surface Fuel Management:<br>• FireSmart thinning treatment to create a 10 m fuel free zone immediately adjacent to the communication structures, and a 10 - 100m thinned zone beyond the fuel free zone. | Polygon is on provincial land with critical infrastructure that if impacted by fire could significantly impact fire and police response in an emergency. The goal of treatment is to make these sites more resilient to fire. |
| Airport | NA | 2 | O1b | 24 | Maintenance burn:<br>• Burn surface grass cover (40 – 60% coverage) every 5-7 years. | Polygon is on municipal land located adjacent to the airport. Minimize smoke impairment for arriving and departing flights. |

### Table 9. Priority fuelbreak areas.

| Treatment Polygon | WUI Threat Plot | Priority | Fuel Type | Approxim-ate Area (ha) | Recommended Treatment Type | Comments |
|---|---|---|---|---|---|---|
| **Fuelbreaks** | | | | | | |
| Coutlee Fuelbreak | 9, 11 | 2 | C3/C4 | 39 | Fuel management:<br>• Prune pine trees up to 2 m;<br>• Thin dense pockets of pine;<br>• Pile and burn wood waste; and<br>• Burn surface grass cover. | This proposed fuelbreak will establish an approximately 250 m free zone along the Coutlee Bench through fuel mitigation activities and reduce the probability and consequence of a catastrophic wildfire moving into the City from the west. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | • Reduce presence/absence of invasive species. | |
| Iron Mountain Fuelbreak | N/A | 1 | C3/C4/ C7/O1b | 290 | Fuel management:<br>• Prune pine trees up to 2 m;<br>• Thin dense pockets of pine;<br>• Pile and burn wood waste; and<br>• Burn surface grass cover.<br>• Reduce presence/absence of invasive species. | This proposed fuelbreak will establish a 300 m free zone along the south side of the Coquihalla Highway through fuel mitigation activities, and reduce the probability and consequence of a wildfire moving into the City from the south. Additionally, fuel management in this area would enhance protection around the Iron Mountain communication tower. |

**Table 10. Summary of Fuel Management recommendations.**

| **Fuel Management** | | | |
|---|---|---|---|
| **Item** | **Priority** | **Recommendation** | **Estimated Cost ($)** |
| **Objective**: Reduce wildfire threat on private and public lands through fuel management. | | | |
| 23 | High | • The City should apply for funding to conduct maintenance for previously treated areas | UBCM SWPI Funding / Municipal Funding |
| 24 | High | • The City should identify potential partnerships to fund establishment of a 3 m fuel-free zone immediately adjacent to the north side of the Central Park Walking Trail. Alternatively, work with the City's Public Works department to implement this treatment by incorporating mitigation into the existing Public Works program | $5,000 |
| 25 | High | • Design, plan and implement a treatment to protect critical infrastructure on Iron Mountain. | $15,000 |
| 26 | Moderate | • Work with BCWS to implement prescribed fire at the airport as part of the training regime for new recruits and the Merritt Fire Zone training centre | Funding through existing programs |
| **Objective:** Establish landscape-level fuelbreaks to enhance community protection. | | | |
| 27 | High | • Seek funding to develop prescriptions for landscape level fuel breaks. The SWPI program currently does not fund these activities; however, expected changes to the program may allow funding in the future. | $10,000 |
| 28 | High | • In cooperation with MFLNRO and forest licensees the City should establish fuelbreaks in the identified areas on Iron Mountain and the Coutlee bench. | Working with Licensees and MFLNRO |

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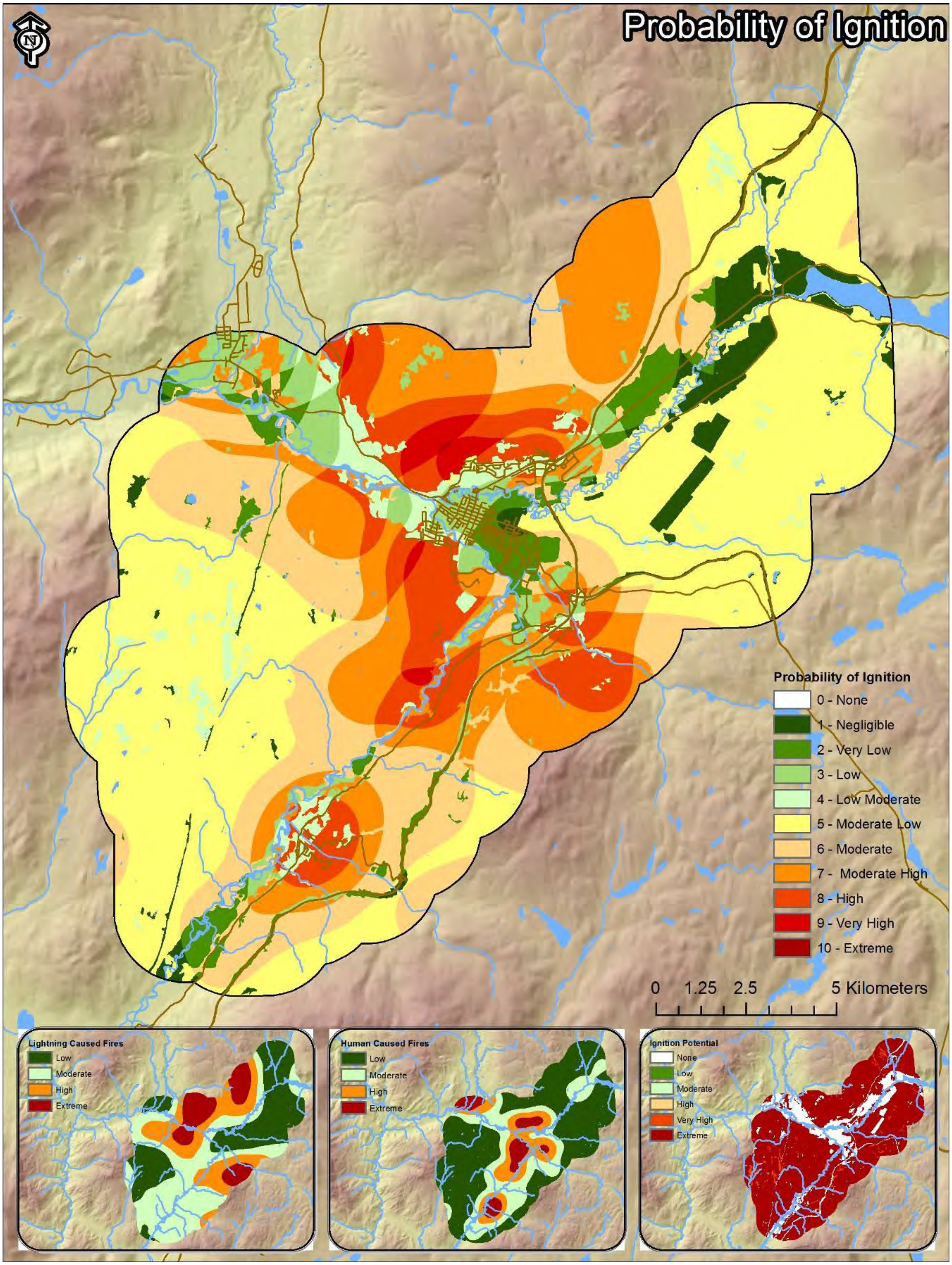
# APPENDIX A: WRMS MAPS

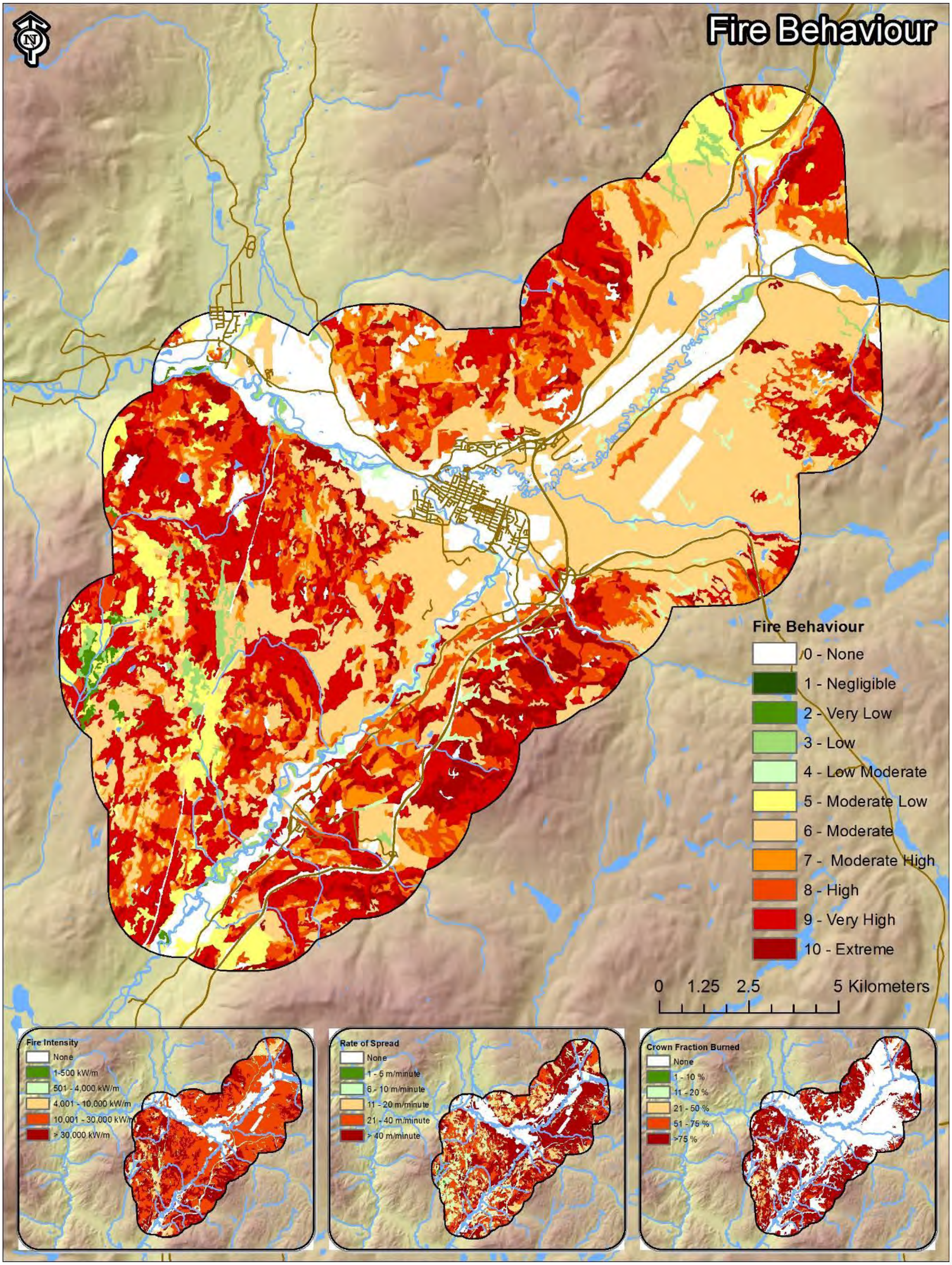
PROBABILITY RATING:

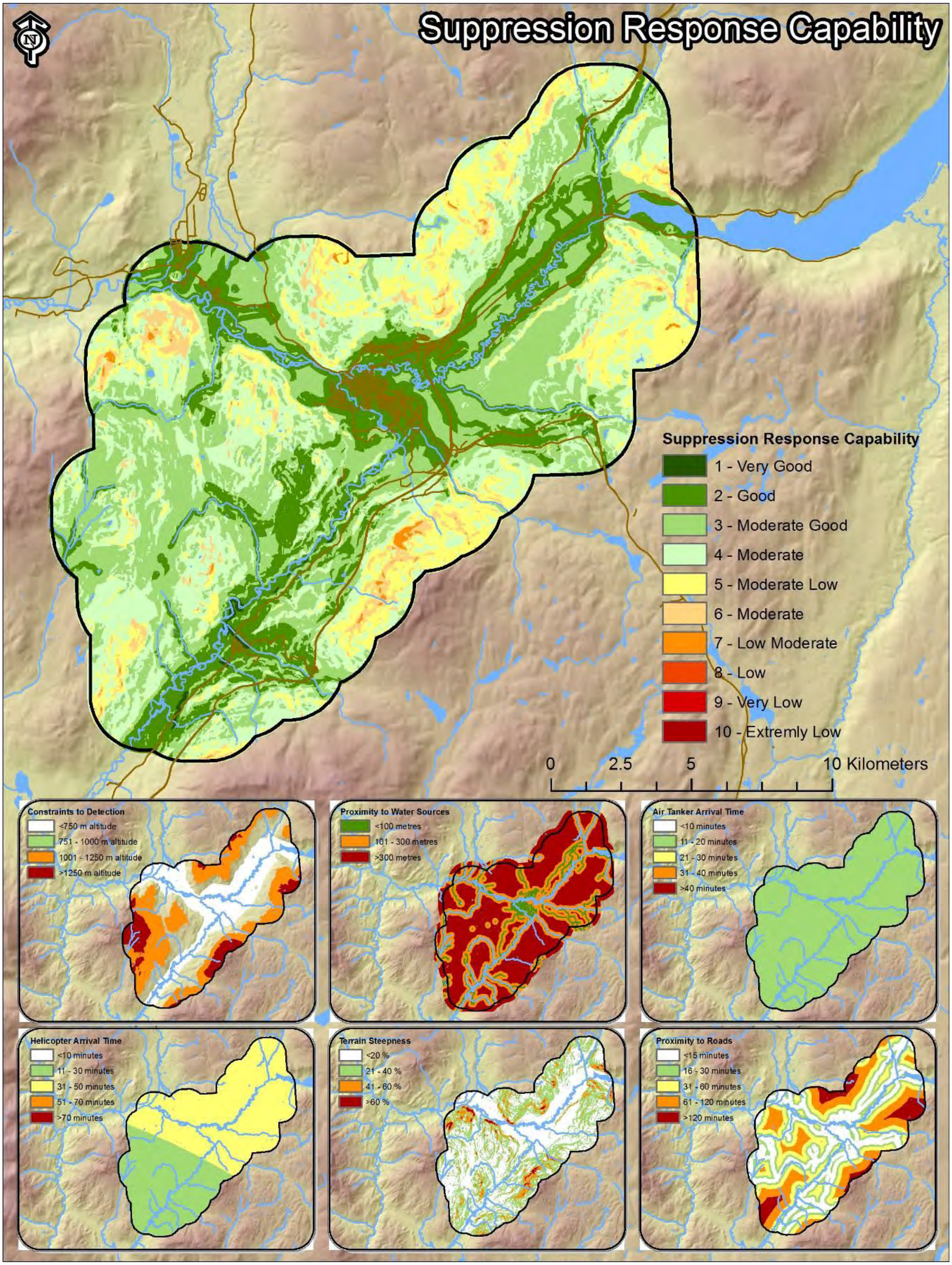
- Probability of Ignition
- Potential Fire Behaviour
- Suppression Capability

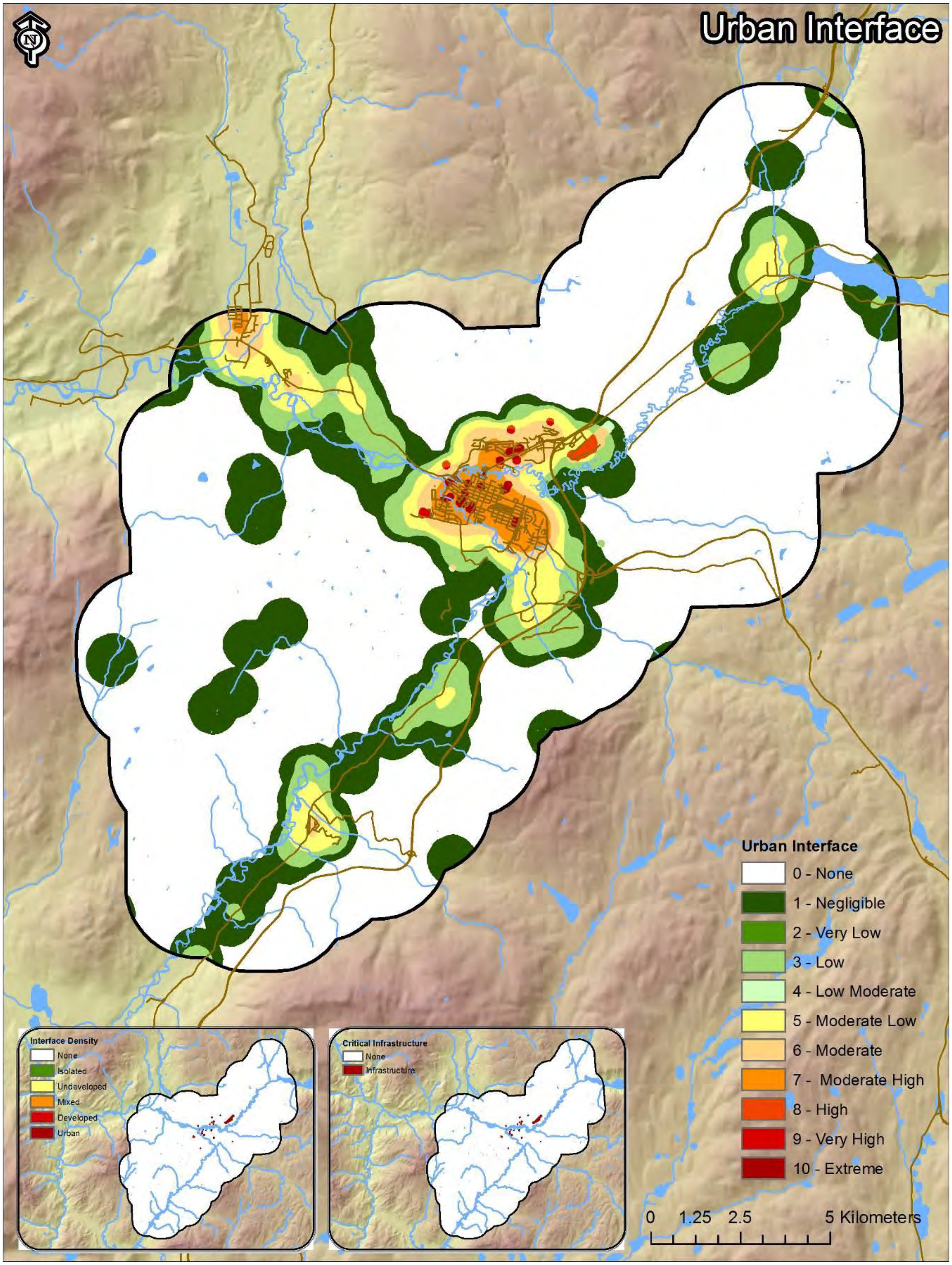
CONSEQUENCE RATING:

- Urban Interface
- Air Quality
- Water Quality
- Ecosystem Integrity


Probability of Ignition
N
Probability of Ignition
0 - None
1 - Negligible
2 - Very Low
3 - Low
4 - Low Moderate
5 - Moderate Low
6 - Moderate
7 - Moderate High
8 - High
9 - Very High
10 - Extreme
0 1.25 2.5 5 Kilometers
Lightning Caused Fires
Low
Moderate
High
Extreme
Human Caused Fires
Low
Moderate
High
Extreme
Ignition Potential
None
Low
Moderate
High
Very High
Extreme


Fire Behaviour
Fire Behaviour
0 - None
1 - Negligible
2 - Very Low
3 - Low
4 - Low Moderate
5 - Moderate Low
6 - Moderate
7 - Moderate High
8 - High
9 - Very High
10 - Extreme
0 1.25 2.5 5 Kilometers
Fire Intensity
None
1-500 kW/m
501 - 4,000 kW/m
4,001 - 10,000 kW/m
10,001 - 30,000 kW/m
> 30,000 kW/m
Rate of Spread
None
1 - 5 m/minute
6 - 10 m/minute
11 - 20 m/minute
21 - 40 m/minute
> 40 m/minute
Crown Fraction Burned
None
1 - 10 %
11 - 20 %
21 - 50 %
51 - 75 %
>75 %


Suppression Response Capability
N
Suppression Response Capability
1 - Very Good
2 - Good
3 - Moderate Good
4 - Moderate
5 - Moderate Low
6 - Moderate
7 - Low Moderate
8 - Low
9 - Very Low
10 - Extremly Low
0 2.5 5 10 Kilometers
Constraints to Detection
<750 m altitude
751 - 1000 m altitude
1001 - 1250 m altitude
>1250 m altitude
Proximity to Water Sources
<100 metres
101 - 300 metres
>300 metres
Air Tanker Arrival Time
<10 minutes
11 - 20 minutes
21 - 30 minutes
31 - 40 minutes
>40 minutes
Helicopter Arrival Time
<10 minutes
11 - 30 minutes
31 - 50 minutes
51 - 70 minutes
>70 minutes
Terrain Steepness
<20 %
21 - 40 %
41 - 60 %
>60 %
Proximity to Roads
<15 minutes
16 - 30 minutes
31 - 60 minutes
61 - 120 minutes
>120 minutes


Urban Interface
Urban Interface
0 - None
1 - Negligible
2 - Very Low
3 - Low
4 - Low Moderate
5 - Moderate Low
6 - Moderate
7 - Moderate High
8 - High
9 - Very High
10 - Extreme
0 1.25 2.5 5 Kilometers
Interface Density
None
Isolated
Undeveloped
Mixed
Developed
Urban
Critical Infrastructure
None
Infrastructure

## Derivation of Urban Interface Consequence Ratings:

**Wildfire Risk Management Theme:** **Consequence**

**Wildfire Risk Management Component:** **Urban Interface**

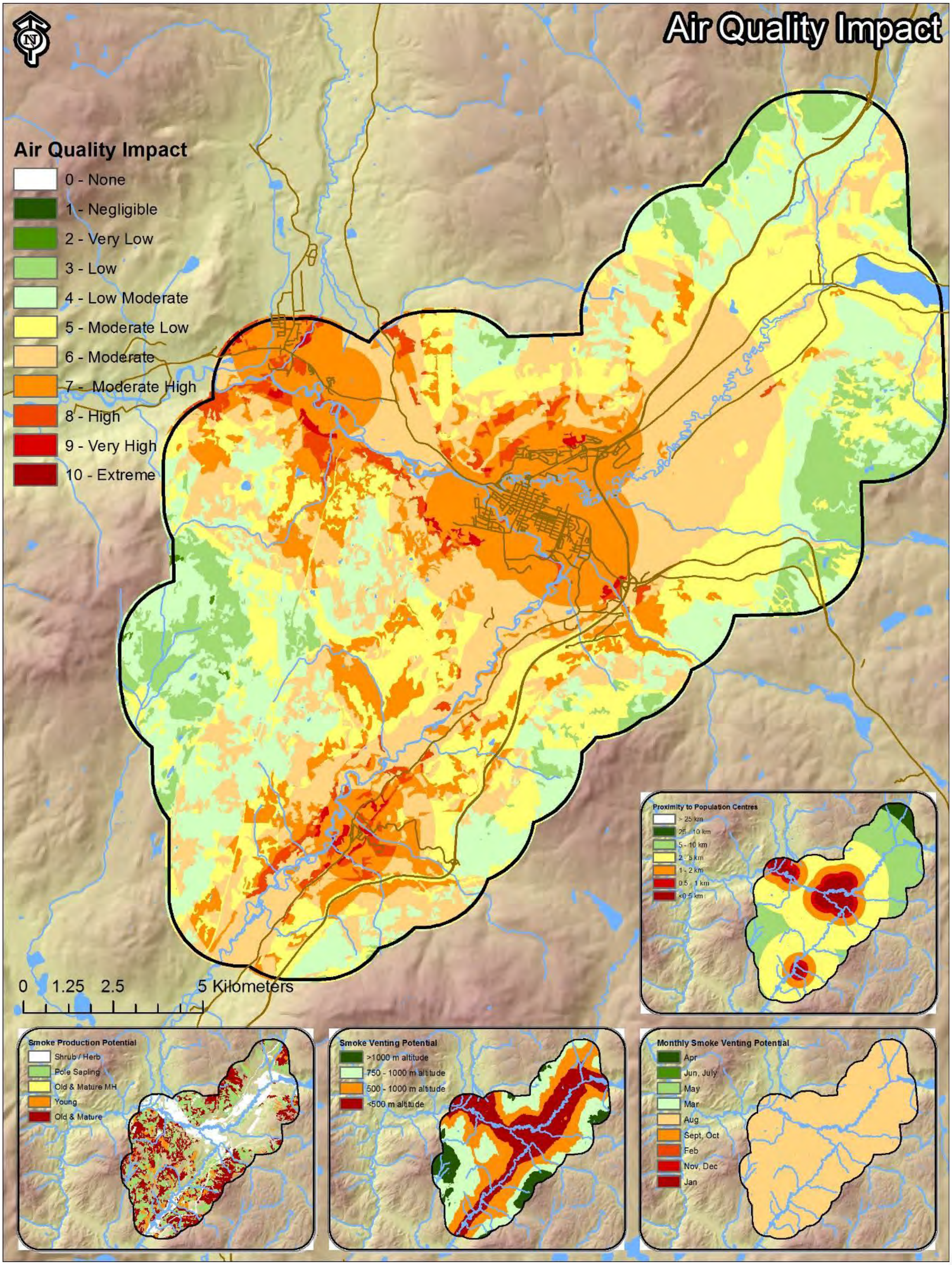
The property component provides a rating of the potential for a fire to pose a direct threat to people and property. The rating is calculated as a weighted sum rating using Interface, Infrastructure, Slope Stability Hazards, and Recreation Use.

**Component Attributes:**

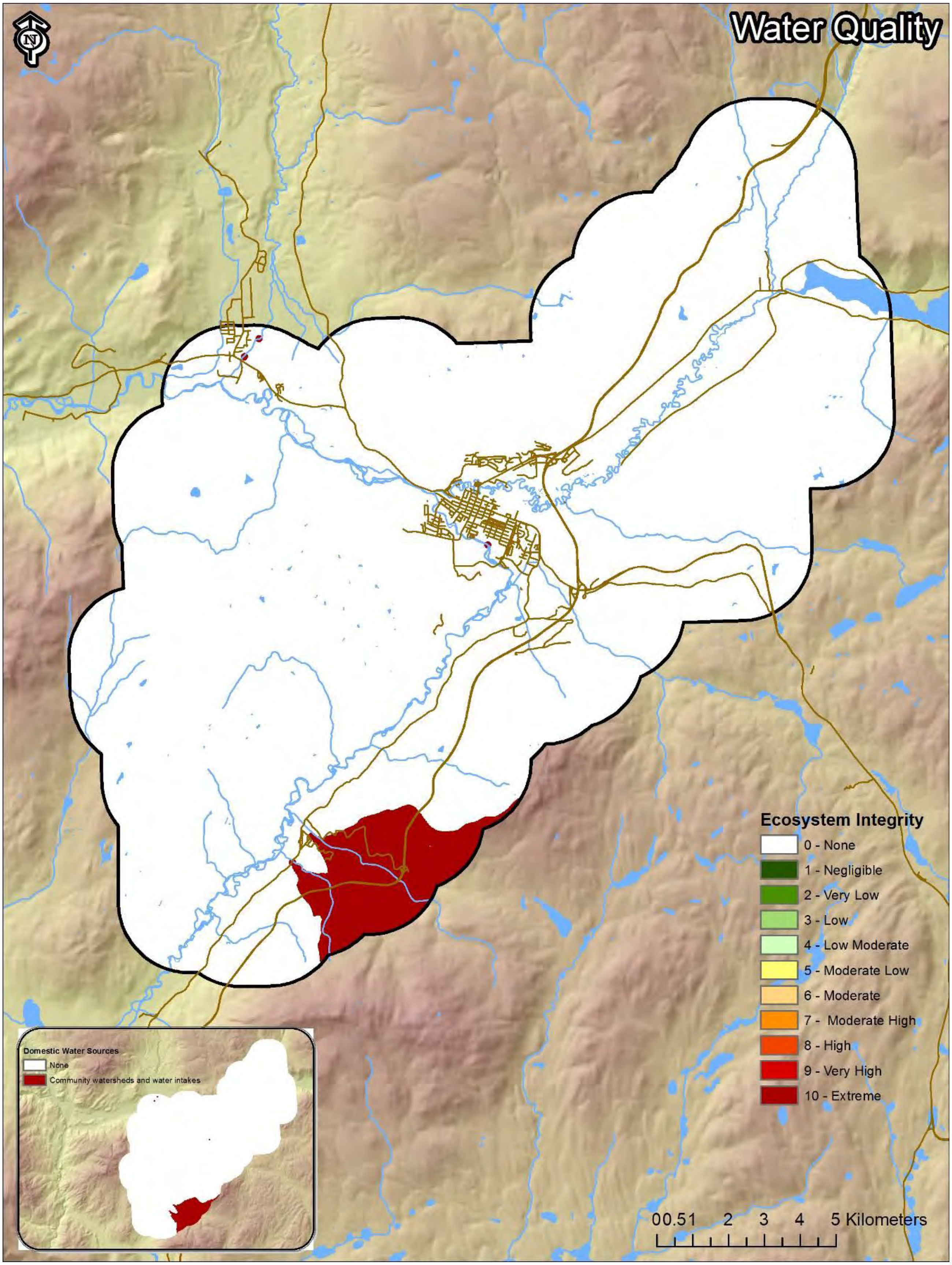
| Attribute | Indicator / Units | Rating Scale | | Weight |
|---|---|---|---|---|
| **Structure Density**<br>*Indicator of threat to private and public property. Density class (from TRIM) = Build-up areas and # of structures/km*2* | Weight by density class | Urban | 10 | 70% |
| | | Developed | 9 | |
| | | Mixed | 7 | |
| | | Undeveloped | 5 | |
| | | Isolated | 2 | |
| | | None | 0 | |
| **Critical Infrastructure**<br>*Special features identified within the study area and rated as extreme (Airport, BC hydro substaion,school, fire-hall, police station, hospital, city hall). Communications, CPR,* | Buffer 100m around features | Buffer | 10 | 30% |

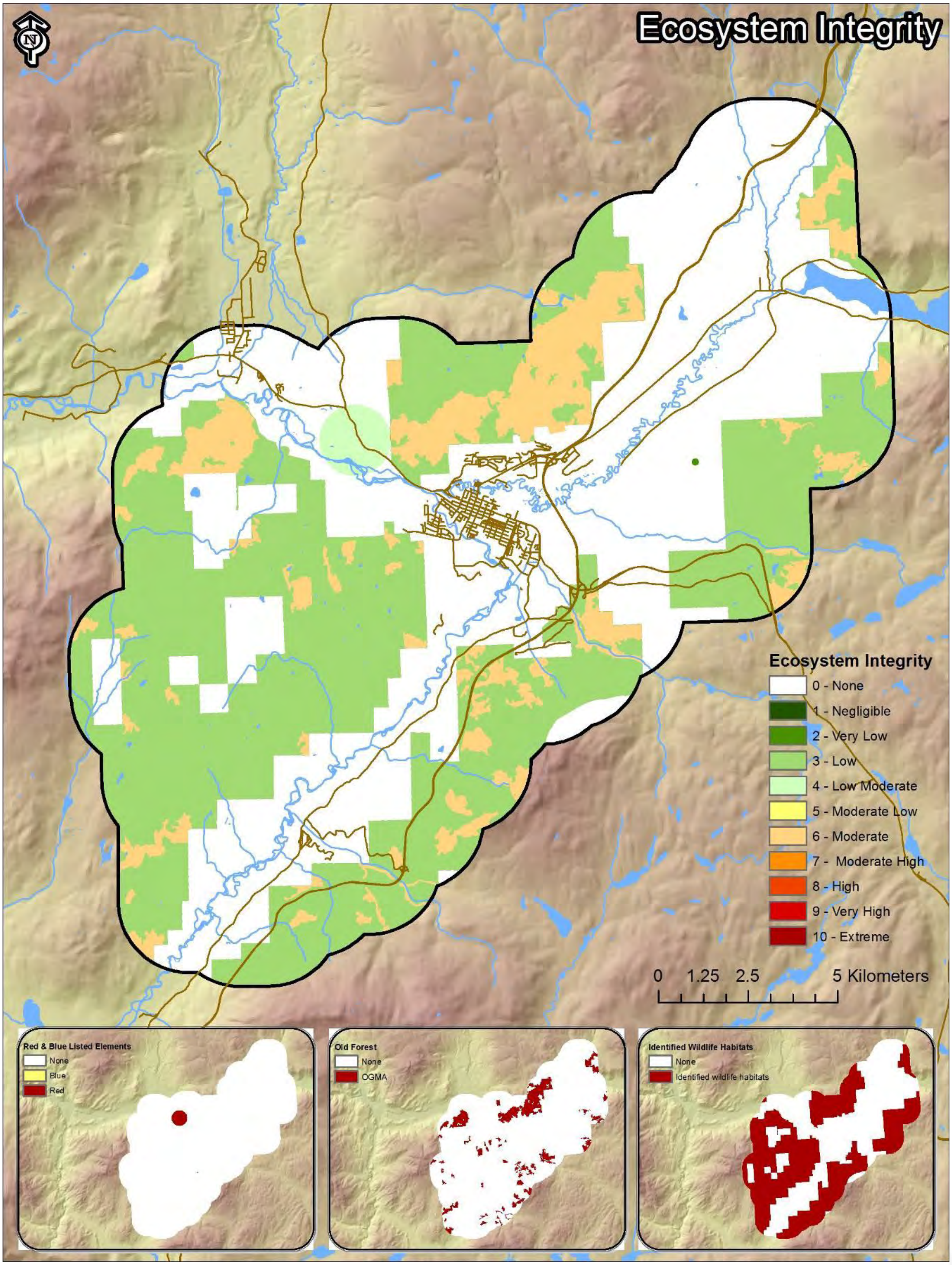
## Structure Density Rating Classes:

| Class | Description |
|---|---|
| Undeveloped | 0-1 structures/km$^2$ |
| Isolated | 1-10 structures/km$^2$ |
| Mixed | 10-100 structures/km$^2$ |
| Developed | 100-1000 structures/km$^2$ |
| Urban | >1000 structures/km$^2$ |



Air Quality Impact
Air Quality Impact
0 - None
1 - Negligible
2 - Very Low
3 - Low
4 - Low Moderate
5 - Moderate Low
6 - Moderate
7 - Moderate High
8 - High
9 - Very High
10 - Extreme
0 1.25 2.5 5 Kilometers
Proximity to Population Centres
> 25 km
25 - 10 km
5 - 10 km
2 - 5 km
1 - 2 km
0.5 - 1 km
<0.5 km
Smoke Production Potential
Shrub / Herb
Pole Sapling
Old & Mature MH
Young
Old & Mature
Smoke Venting Potential
>1000 m altitude
750 - 1000 m altitude
500 - 1000 m altitude
<500 m altitude
Monthly Smoke Venting Potential
Apr
Jun, July
May
Mar
Aug
Sept, Oct
Feb
Nov, Dec
Jan


Water Quality
N
Ecosystem Integrity
0 - None
1 - Negligible
2 - Very Low
3 - Low
4 - Low Moderate
5 - Moderate Low
6 - Moderate
7 - Moderate High
8 - High
9 - Very High
10 - Extreme
Domestic Water Sources
None
Community watersheds and water intakes
0 0.5 1 2 3 4 5 Kilometers


Ecosystem Integrity
Ecosystem Integrity
0 - None
1 - Negligible
2 - Very Low
3 - Low
4 - Low Moderate
5 - Moderate Low
6 - Moderate
7 - Moderate High
8 - High
9 - Very High
10 - Extreme
0 1.25 2.5 5 Kilometers
Red & Blue Listed Elements
None
Blue
Red
Old Forest
None
OGMA
Identified Wildlife Habitats
None
Identified wildlife habitats

# APPENDIX B: LANDSCAPE LEVEL FUELBREAK MANAGEMENT

The information contained within this section has been inserted from "The Use of Fuelbreaks in Landscape Fire Management" by James K. Agee, Benii Bahro, Mark A. Finney, Philip N. Omi, David B. Sapsis, Carl N. Skinner, Jan W. van Wagtendonk, and C. Phill Weatherspoon. This article succinctly describes the principles and use of fuelbreaks in landscape fire management.

The principal objective behind the use of fuelbreaks, as well as any other fuel treatment, is to alter fire behaviour over the area of treatment. As discussed above, fuelbreaks provide points of anchor for suppression activities.

### Surface Fire Behaviour:

Surface fuel management can limit fireline intensity (Byram 1959) and lower potential fire severity (Ryan and Noste 1985). The management of surface fuels so that potential fireline intensity remains below some critical level can be accomplished through several strategies and techniques. Among the common strategies are fuel removal by prescribed fire, adjusting fuel arrangement to produce a less flammable fuelbed (e.g., crushing), or "introducing" live understory vegetation to raise average moisture content of surface fuels (Agee 1996). Wildland fire behaviour has been observed to decrease with fuel treatment (Buckley 1992), and simulations conducted by van Wagtendonk (1996) found both pile burning and prescribed fire, which reduced fuel loads, to decrease subsequent fire behaviour. These treatments usually result in efficient fire line construction rates, so that control potential (reducing "resistance to control") can increase dramatically after fuel treatment.

The various surface fuel categories interact with one another to influence fireline intensity. Although more litter and fine branch fuel on the forest floor usually results in higher intensities however that is not always the case. If additional fuels are packed tightly (low fuelbed porosity), they may result in lower intensities. Although larger fuels (>3 inches) - are not included in fire spread models, as they do not usually affect the spread of the fire (unless decomposed [Rothennel 1991]), they may result in higher energy releases over longer periods of time when a fire occurs, having significant effects on fire severity, and they reduce rates of fireline construction.

The effect of herb and shrub fuels on fireline intensity is not simply predicted. First of all, more herb and shrub fuels usually imply more open conditions. These should be associated with lower relative humidity and higher surface windspeeds. Dead fuels may be drier - and the rate of spread may be higher - because of the altered microclimate compared to more closed canopy forest with less understorey. Live fuels, with higher foliar moisture while green, will have a dampening effect on fire behaviour. However, if the grasses and forbs cure, the fine dead fuel can increase fireline intensity and localized spotting.

### Conditions That Initiate Crown Fire:

A fire moving through a stand of trees may move as a surface fire, an independent crown fire, or as a combination of intermediate types of fire (Van Wagner 1977). The initiation of crown fire behaviour is a function of surface fireline intensity and of the forest canopy: its height above ground and moisture content (Van Wagner 1977). The critical surface fire intensity needed to initiate crown fire behaviour can be calculated for a range of crown base heights and foliar moisture contents, and represents the minimum level of fireline intensity necessary to initiate crown fire (Table 1); Alexander 1988, Agee 1996). Fireline intensity or flame length below this critical level may result in fires that do not crown but may still be of stand replacement severity. For the limited range of crown base heights and foliar moistures shown in Table 11, the critical levels of flame length appear more sensitive to height to crown base than to foliar moisture (Alexander 1988).

**Table 11. Flame lengths associated with critical levels of fireline intensity that are associated with initiating crown fire, using Byram's (1959) equation.**

| Foliar Moisture Content (%) | Height of Crown Base Separation | | | |
|---|---|---|---|---|
| | 2 meters | 6 meters | 12 meters | 20 meters |
| | 6 feet | 20 feet | 40 feet | 66 feet |
| | M ft | M ft | M ft | M ft |
| 70 | 1.1 4 | 2.3 8 | 3.7 12 | 5.3 17 |
| 80 | 1.2 4 | 2.5 8 | 4.0 13 | 5.7 19 |
| 90 | 1.3 4 | 2.7 9 | 4.3 14 | 6.1 20 |
| 100 | 1.3 4 | 2.8 9 | 4.6 15 | 6.5 21 |
| 120 | 1.5 5 | 3.2 10 | 5.1 17 | 7.3 24 |

If the structural dimensions of a stand and information about foliar moisture are known, then critical levels of fireline intensity that will be associated with crown fire for that stand can be calculated. Fireline intensity can be predicted for a range of stand fuel conditions, topographic situations such as slope and aspect, and anticipated weather conditions, making it possible to link on-the-ground conditions with the initiating potential for crown fires. In order to avoid crown fire initiation, fireline intensity must be kept below the critical level. Managing surface fuels can accomplish this such that fireline intensity is kept well below the critical level or by raising crown base heights such that the critical fireline intensity is difficult to reach. In the field, the variability in fuels, topography and microclimate will result in varying levels of potential fireline intensity, critical fireline intensity, and therefore varying crown fire potential.

**Conditions That Allow Crown Fire To Spread**:
The crown of a forest is similar to any other porous fuel medium in its ability to burn and the conditions under which crown fire will or will not spread. The heat from a spreading crown fire into unburned crown ahead is a function of the crown rate of spread, the crown bulk density, and the crown foliage ignition energy. The crown fire rate of spread is not the same as the surface fire rate of spread, and often includes effects of short-range spotting. The crown bulk density is the mass of crown fuel, including needles, fine twigs, lichens, etc., per unit of crown volume (analogous to soil bulk density). Crown foliage ignition energy is the net energy content of the fuel and varies primarily by foliar moisture content, although species differences in energy content are apparent (van Wagtendonk et al. 1998). Crown fires will stop spreading, but not necessarily stop torching, if either the crown fire rate of spread or crown bulk density falls below some minimum value.

If surface fireline intensity rises above the critical surface intensity needed to initiate crown fire behaviour, the crown will likely become involved in combustion. Three phases of crown fire behaviour can be described by critical levels of surface fireline intensity and crown fire rates of spread (Van Wagner 1977, 1993): (1) a passive crown fire, where the crown fire rate of spread is equal to the surface fire rate of spread, and crown fire activity is limited to individual tree torching; (2) an active crown fire, where the crown fire rate of spread is above some minimum spread rate; and (3) an independent crown fire, where crown fire rate of spread is largely independent of heat from the surface fire intensity. Scott and Reinhardt (in prep.) have defined an additional class, (4) conditional surface fire, where the active crowning spread rate exceeds a critical level, but the critical level for surface fire intensity is not met. A crown fire will not initiate from a surface fire in this stand, but an active crown fire may spread through the stand if it initiates in an adjacent stand.

Critical conditions can be defined below which active or independent crown fire spread is unlikely. To derive these conditions, visualize a crown fire as a mass of fuel being carried on a "conveyor belt" through a stationary flaming front. The amount of fine fuel passing through the front per unit time (the mass flow rate) depends on the speed of the conveyor belt (crown fire rate of spread) and the density of the forest crown fuel (crown bulk density). If the mass flow rate falls below some minimum level (Van Wagner 1977) crown fires will not spread. Individual crown torching, and/or crown scorch of varying degrees, may still occur.

Defining a set of critical conditions that may be influenced by management activities is difficult. At least two alternative methods can define conditions such that crown fire spread would be unlikely (that is, mass flow rate is too low). One is to calculate critical windspeeds for given levels of crown bulk density (Scott and Reinhardt, in prep.), and the other is to define empirically derived thresholds of crown fire rate of spread so that critical levels of crown bulk density can be defined (Agee 1996). Crown bulk densities of 0.2 kg $m^{-3}$ are common in boreal forests that burn with crown fire (Johnson 1992), and in mixed conifer forests, Agee (1996) estimated that at levels below 0.10 kg $m^{-3}$ crown fire spread was unlikely, but no definitive single "threshold" is likely to exist.

Therefore, reducing surface fuels, increasing the height to the live crown base, and opening canopies should result in (a) lower fire intensity, (b) less probability of torching, and (c) lower probability of independent crown fire. There are two caveats to these conclusions. The first is that a grassy cover is often preferred as the fuelbreak ground cover, and while fireline intensity may decrease in the fuelbreak, rate of spread may increase. Van Wagtendonk (1996) simulated fire behaviour in untreated mixed conifer forests and fuelbreaks with a grassy understory, and found fireline intensity decreased in the fuelbreak (flame length decline from 0.83 to 0.63 m [2.7 to 2.1 ft]) but rate of spread in the grassy cover increased by a factor of 4 (0.81 to 3.35 m/min [2.7-11.05 ft/min]). This flashy fuel is an advantage for backfiring large areas in the fuelbreak as a wildland fire is approaching (Green 1977), as well as for other purposes described later, but if a fireline is not established in the fuelbreak, the fine fuels will allow the fire to pass through the fuelbreak quickly. The second caveat is that more open canopies will result in an altered microclimate near the ground surface, with somewhat lower fuel moisture and higher windspeeds in the open understory (van Wagtendonk 1996).

### Fuelbreak Effectiveness:

The effectiveness of fuelbreaks continues to be questioned because they have been constructed to varying standards, "tested" under a wide variety of wildland fire conditions, and measured by different standards of effectiveness. Green (1977) describes a number of situations where traditional fuelbreaks were successful in stopping wildland fires, and some where fuelbreaks were not effective due to excessive spotting of wildland fires approaching the fuelbreaks.

Fuelbreak construction standards, the behaviour of the approaching wildland fire, and the level of suppression each contribute to the effectiveness of a fuelbreak. Wider fuelbreaks appear more effective than narrow ones. Fuel treatment outside the fuelbreak may also contribute to their effectiveness (van Wagtendonk 1996). Area treatment such as prescribed fire beyond the fuelbreak may be used to lower fireline intensity and reduce spotting as a wildland fire approaches a fuelbreak, thereby increasing its effectiveness. Suppression forces must be willing and able to apply appropriate suppression tactics in the fuelbreak. They must also know that the fuelbreaks exist, a common problem in the past. The effectiveness of suppression forces depends on the level of funding for people, equipment, and aerial application of retardant, which can more easily reach surface fuels in a fuelbreak. Effectiveness is also dependent on the psychology of firefighters regarding their safety. Narrow or unmaintained fuelbreaks are less likely to be entered than wider, well-maintained ones.

No absolute standards for width or fuel manipulation are available. Fuelbreak widths have always been quite variable, in both recommendations and construction. A minimum of 90 m (300 ft) was typically specified for primary fuelbreaks (Green 1977). As early as the 1960's, fuelbreaks as wide as 300 m (1000 ft) were included in gaming simulations of fuelbreak effectiveness (Davis 1965), and the recent proposal for northern California national forests by the Quincy Library Group (see web site http://www.qlg.org for details) includes fuelbreaks 390 m (0.25 mi) wide. Fuelbreak simulations for the Sierra Nevada Ecosystem Project (SNEP) adopted similar wide fuelbreaks (van Wagtendonk 1996, Sessions et al. 1996).

Fuel manipulations can be achieved using a variety of techniques (Green 1977) with the intent of removing surface fuels, increasing the height to the live crown of residual trees, and spacing the crowns to prevent independent crown fire activity. In the Sierra Nevada simulations, pruning of residual trees to 3 m (10 ft) height was assumed, with canopy cover at 1-20% (van Wagtendonk 1996). Canopy cover less than 40% has been proposed for the Lassen National Forest in northern California. Clearly, prescriptions for creation of fuelbreaks must not only specify what is to be removed, but must describe the residual structure in terms of standard or custom fuel models so that potential fire behaviour can be analyzed.