West Metro Fire Rescue
Lakewood, C0

Community Wildfire Protection Plan Update

May 2021

ANCHORPOINT
WILDLAND FIRE SOLUTIONS

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MUTUAL AGREEMENT PAGE

This Community Wildfire Protection Plan developed by West Metro Fire Rescue:

- Was collaboratively developed. Interested parties, fire management agencies, and state and county land management agencies managing land in or adjacent to the study area have been consulted.
- This plan identifies and prioritizes areas for hazardous fuel reductions treatments and recommends the types of treatment that will aid in protecting communities in the study area.
- This plan recommends measures to reduce the ignitability of structures throughout the area addressed by the plan.

The following entities attest the standards listed above have been met and mutually agree with the content of this Community Wildfire Protection Plan:

West Metro Fire Rescue, by Don Lombardi, Fire Chief

Colorado State Forest Service, Golden District, by Nate Beckman, Supervisory Forester

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Colorado State Forest Service, Franktown District, by Meg Halford, Supervisory Forester

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USFS Pike/San Isabell, by Joe Sean Kennedy, District Fire Management Officer

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Jefferson County Sheriff's Office - Emergency Management, by Kevin Michalak, Fire Management Officer

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Douglas County Sheriff's Office – Emergency Management, by Mike Alexander, Fire Management Officer

INTRODUCTION

This CWPP update was developed at the request of West Metro Fire Rescue (WMFR) with the support of Jefferson County, Colorado, Douglas County, Colorado, and the Colorado State Forest Service (CSFS). Information in this plan will be provided at the level of specificity determined by the community and appropriate agencies.

This document presents the results of a study to identify and quantify changes in conditions or values at risk that could affect fire protection planning and response in the Wildland-Urban Interface (WUI) and Wildland Intermix (WI) portions of the study area. The WUI is also known as the Urban Edge Ember Zone. It is the area where encroaching wildland fuels could create a fire hazard to what would be an urban development in a different setting. The WI consists of communities where wildland fuels surround homes.

This report neither replaces nor intends to duplicate information found in the 2006 joint Jefferson County/West Metro Fire Rescue Plan or the 2020 Roxborough Park CWPP. The original Jefferson County/West Metro CWPP was a county-wide effort developed at a macro level. This study provides a more detailed analysis of the WUI and WI areas included in the WMFR boundary. As such, it should be considered an updated supplement to the 2006 CWPP. Some information regarding Roxborough Park has been incorporated from their 2020 CWPP; however, coverage of Ravenna/Roxborough Park and Roxborough Village has been expanded with a new analysis and recommendations to provide consistency with the rest of the WMFR study area.

This study focuses on areas of the highest residential density and deals primarily with life safety and structural ignitability. Future updates may be necessary should the need arise to focus on unpopulated land, sparsely populated areas, other values at risk, or areas of special interest.

A current analysis of the probability of a severe fire occurrence and expected severity of fire effects using updated technology and a detailed discussion of structural ignitability are included in this study. This information allows for the prioritization of mitigation efforts. From an analysis of this data, solutions and mitigation recommendations are provided to aid land managers, residents, fire officials, and other collaborators in planning and implementation. This format is designed to help communities clarify and refine priorities for protecting life, property, and critical infrastructure in the WUI/WI. It can also lead community members through valuable discussions regarding management options and implications for any areas of special interest.

Definitions

For the purposes of this report, the following definitions apply:

FireShed - No-HARM divides the landscape into units based on topography. FireSheds tend to correlate to the vegetation, and the direction fires will burn in the absence of wind. FireSheds are helpful for dividing the landscape into planning units and providing data in a spatial context that matches fire behavior. FireShed units tend to be roughly 150 to 200 acres in size.

Frequency - A simulation-based prediction of the probability of future wildfire occurrences derived from No-HARM. No-HARM assigns a numeric value of 1-50, where one is the least likely for a wildfire occurrence, and 50 is the most likely. Frequency is different from probability of ignition in that frequency only considers ignitions likely to develop into fires large enough to create a significant threat to Values at Risk.

Hazard - The combination of the Wildfire Hazard Ratings (WHR) of the WUI/WI neighborhood surveys and the fire behavior potential analysis, which is derived from No-HARM Severity analysis outputs. The principle elements of the WHR analysis have been integrated into the No-HARM model in this report to provide a single measure of hazard in the developed portions of the study area. Hazard attempts to quantify the severity of undesirable outcomes to the values at risk.

No-HARM - The National Hazard and Risk Model (No-HARM) is a decision support tool for wildfire hazard assessment. No-HARM calculates relative fire danger ratings by taking the predicted severity and the predicted frequency of wildfire in a given location and incorporating elements that affect the vulnerability of structures in and around communities. No-HARM provides a comprehensive view of the threat context a structure, or group of structures is exposed to during a wildland fire.

Probability - The likelihood of a significant fire occurrence. This is primarily determined by the fire history of the area and a probability model (Frequency) derived from No-HARM.

Risk 50 - The result of the No-HARM composite analysis of Frequency, Severity, and other input variables. By combining the likelihood of a significant fire occurrence and the severity of undesirable fire effects to the values at risk, Risk 50 assigns a numeric value to FireSheds where a 1 represents the lowest level of risk and 50 represents the most extreme level of risk.

Severity - An estimate derived from No-HARM of how severe fire behavior would be in the event of an ignition. No-HARM assigns a numeric value of 1-50, where 1 is the lowest severity and 50 is the highest.

Values at Risk - The tangible values identified by citizens and collaborators as essential to life in the study area (e.g., life safety, property conservation, and critical infrastructure.)

Web Map Interface (WMI) -A web-based user interface specifically designed to warehouse and utilize the No-HARM data and the integration of community assessments. The WMI enables users to visualize a community or parcel-level map with their wildfire hazards.

Wildfire Hazard Rating (WHR) - A model designed to evaluate communities within the Wildland Urban Interface/Wildland Intermix (WUI/WI) for their relative wildfire hazard. WHR focuses on structural ignitability and suppression factors and uses a different rating system from No-HARM, which focuses on the Frequency and Severity of fire in the wildland fuels of the FireSheds. The analysis in this report incorporates the principal elements of the WHR model into the No-HARM model to provide a complete examination in one rating system.

Wildland Intermix (WI) – Areas of concentrated residential development (communities) where wildland fuels surround homes. Homes in these areas exist in the context of natural fuels rather than as typical urban development.

Wildland-Urban Interface (WUI) – (AKA Urban Edge Ember Zone). The area where encroaching wildland fuels could create a fire hazard to structures that in a different setting would be considered a traditional urban development.

GOALS AND OBJECTIVES

Strategic goals for this project include the following:

1. Enhance the life safety of the residents, visitors, and responders.
2. Present methods to mitigate undesirable fire effects on property, infrastructure, and the environment.
3. Enhance previous and existing efforts.

To accomplish these goals, the following objectives have been identified for this report:

1. Establish an approximate level of probability (the likelihood of a significant wildfire event in the study area).
2. Provide a scientific analysis of the fire behavior potential of the study area.
3. Group relatively densely populated areas into residential "Hazard Zones" that represent relatively similar hazard factors.
4. Identify and quantify factors that limit (mitigate) undesirable fire effects to the Values at Risk and recommend actions to reduce those hazards.
5. Quantify any significant changes related to hazards or Values at Risk that have taken place since the Jefferson County/West Metro CWPP was written in 2006.

WMFR recognizes the potential for complex problems associated with achieving fire safety and healthy forest management and a need to balance this mission with environmental and economic concerns of the residents.

UNDERSTANDING NO-HARM RATINGS

No-HARM Severity ratings attempt to quantify the severity of fire effects on values at risk and the ecosystem by combining flame length and crown fire development into a single rating. Like other numeric ratings generated by No-HARM, Severity assigns a value between one and 50 to each FireShed based on an aggregation of all the pixels in that FireShed. A value of one indicates the lowest severity of damaging fire effects and 50 the highest. It is essential to understand the Severity model may under-predict the effects of ember cast, especially under extreme weather conditions.

The No-HARM Risk 50 rating is a mathematical model combining Severity with Frequency. That is to say, the model takes into account both the likelihood of a significant fire developing within the rated FireShed and the severity of damaging fire effects to create a composite rating of fire risk in that FireShed. Although most of the weighting in the model is in these two elements, other factors are included in the Risk 50 rating. They vary depending on whether FireSheds are located in the Wildland-Urban Interface (WUI), Wildland Intermix (WI), or wildland. As with other No-HARM ratings, a value of one indicates the lowest risk and 50 the highest.

No-HARM is based on an analysis of wildland fire behavior and, other than the exclusion of non-burnable areas, does not take structural flammability into consideration. To provide a complete analysis in a single rating scale, the principal elements of the WHR model of structural ignitibility and operational response factors have been incorporated into the No-HARM Risk 50 rating for the residential hazard zones described in this study.

WHR was explicitly developed to evaluate communities within the WUI/WI for their relative wildfire hazard. The WHR model combines physical infrastructure such as structure density and roads, and the fire behavior Severity modeling of No-HARM, with the field experience and knowledge of wildland fire experts. It has been proven and refined by use in rating thousands of neighborhoods throughout the United States. Much of NFPA 1144 has been integrated into this methodology to ensure compatibility with national standards. Additionally, aspects of NFPA 1142 regarding water supply for rural and suburban firefighting are included in the assessments by looking at the proximity and capacity of the water supply.

This model was developed from the perspective of performing structural triage on a threatened community in the path of an advancing wildfire with No-HARM predicted fire behavior for average conditions on a fire season day. The WHR survey and fuel model ground-truthing are accomplished by field surveyors with WUI/WI fire experience. WHR ratings are related to what's customary for the area. For example, a high-hazard area on the plains of Kansas may not look like a high-hazard area in the Sierra-Nevada. The system creates a relative ranking of community hazards in relation to the other communities in the study area. For the No-HARM analysis of the residential Hazard Zones described in the *Community Ignitability Analysis* section of this report, WHR ratings have been incorporated into the No-HARM Risk 50 rating for each Hazard Zone.

COMMUNITY IGNITABILITY ANALYSIS AND RECOMMENDATIONS

Purpose

The purpose of dividing residential areas into hazard zones is to perform a structural ignitability analysis to sort residential areas into hazard categories to prioritize recommendations. This is accomplished by using No-HARM ratings weighted with the Wildfire Hazard Rating (WHR) tool, which is intended to analyze Wildland Urban Interface and Wildland Intermix (WUI/WI) development.

Methodology

No-HARM Risk 50 ratings, weighted with the WHR model described above, have been included in the description of the residential Hazard Zones presented below. Adjective ratings in No-HARM are as follows: 14 or less = Low, 15-23 = Moderate, 24-29 = High, and >29 = Very High. For an introduction to the methodology behind these ratings, please see the *Understanding No-HARM Ratings* section of this report. For a more detailed explanation of No-HARM ratings and their context in this study area, please see the WMI. A field analysis by a Wildland Fire Mitigation Specialist verifies this information and adjusts the final ratings if necessary.

Description

There are twelve residential hazard zones in the study area. No-HARM calculates a Risk 50 score that sorts these zones into one of four adjective rating categories: low, moderate, high, and very high. These residential hazard zone boundaries are different from the "community" boundaries described in the 2006 CWPP due to physical changes caused by additional development, improvements in hazard and probability analysis methodology, and other information provided by NoHARM. This update also includes communities located in Douglas County which were not included in the 2006 CWPP.

The following Hazard Zone descriptions are an overview of the general characteristics of the area. They focus on the built environment and vegetation based on field observations. This overview is not intended to describe every home or street but rather what is average or typical for that zone. The zone descriptions and recommendations will also be available through the Web Map Interface. The WMI will allow the user to zoom in to any area and get more specific information about the physical environment.

Table 1 Hazard Zones in Project Area

West Metro Fire Rescue Communities Risk 50 Hazard Ratings		
Community Name	**Score**	**Adjective Rating**
Clear Creek Corridor - North	22	Moderate
Clear Creek Corridor - South	28	High
South Table Mountain	28	High
Green Mountain Park	28	High
Green Mountain Ravines	25	High
N. Morrison/Red Rocks	23	Moderate
Morrison Town Center	35	Very High
South Morrison	31	Very High
Willow Springs North Ranch	33	Very High
Ken Caryl Valley	19	Moderate
Roxborough Ravenna	35	Very High
Roxborough Village	16	Moderate
Rating Categories: Low < 15; Moderate 15-23; High 24-29; Very High > 29.		

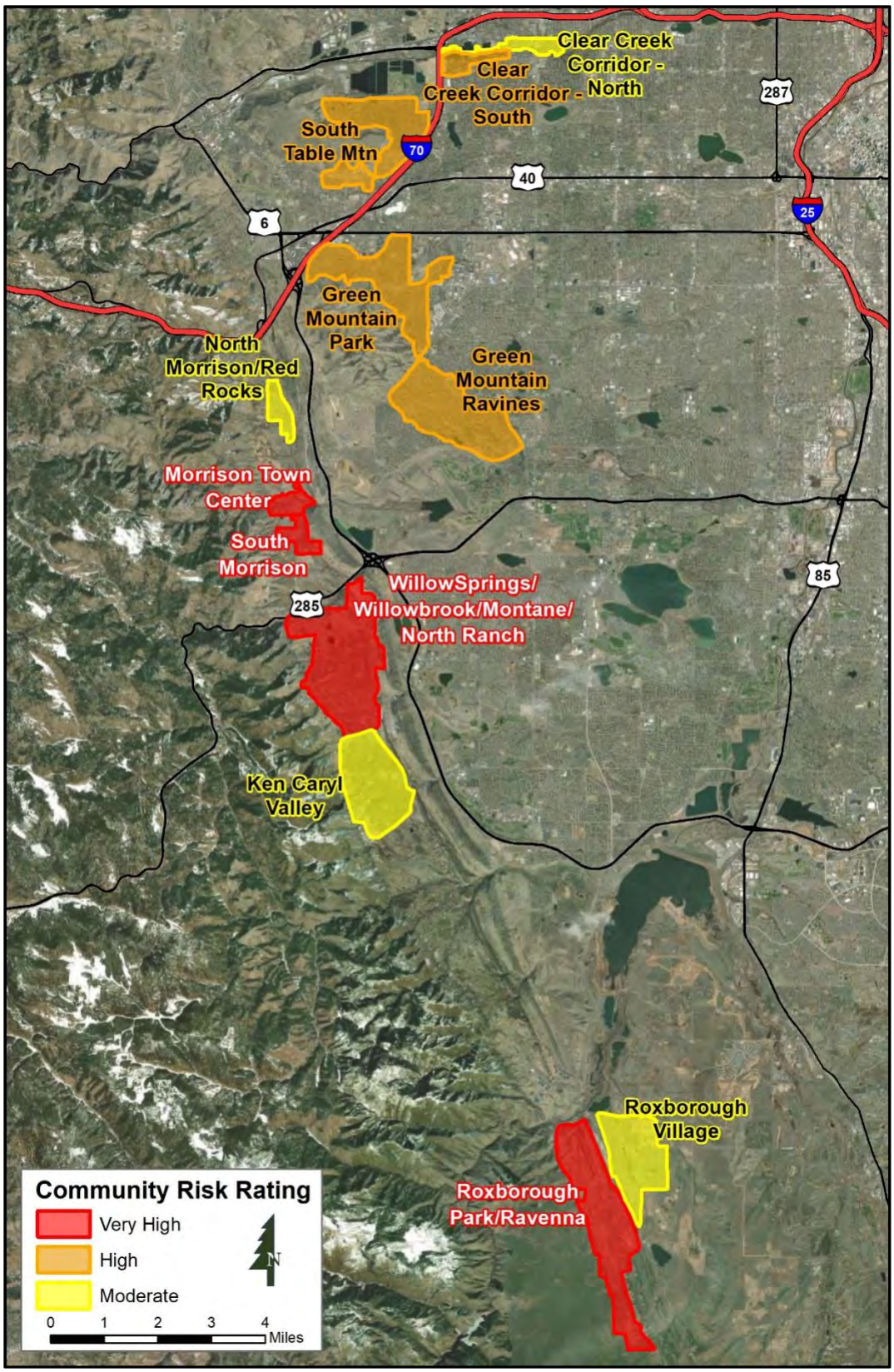
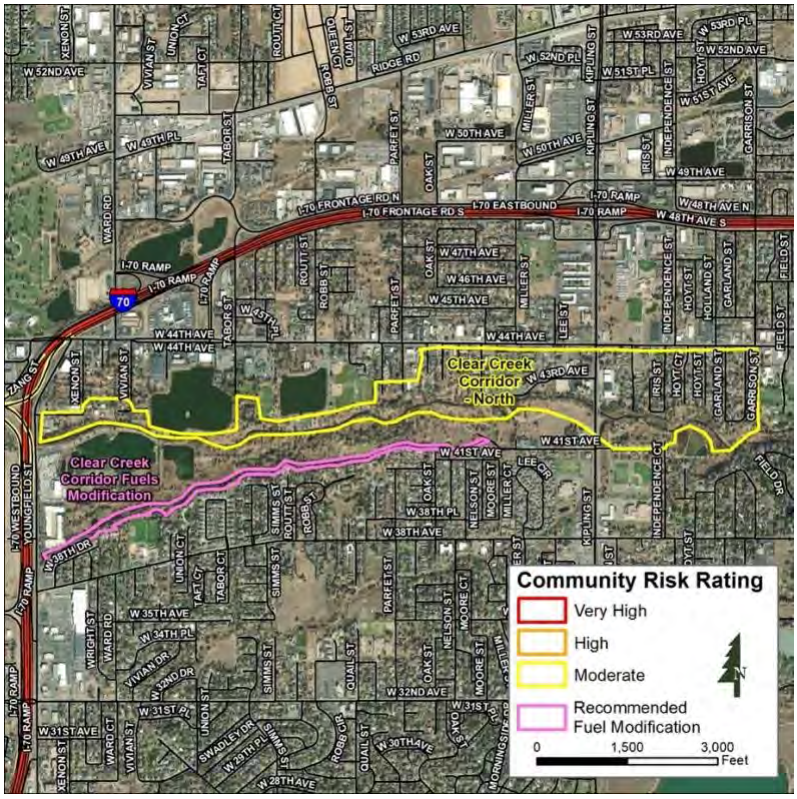


Figure 1 Hazard Zones with No-HARM Rating

Structural Ignitability Discussion, Clear Creek Corridor North – Hazard Zone A



Clear Creek Corridor, North

Hazard Rating:	**Moderate**
Utilities Above or Below Ground:	Above
General Construction:	Wood siding, ignition resistant roofs
Average Lot Size:	Small
Dual Access Roads:	No, most homes on dead ends and loops
Road Widths, Slope and Surface:	Generally good
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 1.4 miles

Zone Characteristics and Hazards

Mostly single-family residences on small lots, but there are some apartment buildings especially on the east end of this community. Most homes are small, wood siding structures with asphalt roofs. Most of the apartment buildings are wood siding with ignition resistant trim (usually brick) and asphalt roofs. Some homes have flammable outbuildings, equipment or other items stored in yards. Wooden fences and decks are common. Very few of the single-family dwellings have any defensible space. Many homes have flammable ornamental vegetation planted too close to structures. There are overhead powerlines in this community. Native vegetation consists primarily of light to moderately heavy loads of grasses with scattered patches of deciduous timber, especially riparian species along the creek. Topography is flat to low slopes without complex features. Roads are paved and of adequate width, but most of the homes are located on dead ends and cul de sacs with no alternative access and poor turnarounds for apparatus. Street signs are reflective, but address markers are inconsistent, usually not reflective, or missing entirely. This community borders heavily used open space and several fires have been started by illegal camping and transients.

Recommendations

- Defensible space for homes adjacent to the open space is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Clear Creek Corridor South – Hazard Zone B

Clear Creek Corridor, South - Hazard Zone B

Hazard Rating:	**High**
Utilities Above or Below Ground:	Above ground power lines
General Construction:	Primarily combustible siding w/IR trim and IR roof
Average Lot Size:	Small
Dual Access Roads:	No
Road Widths, Slope and Surface:	Paved and generally good width
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately .75 mile

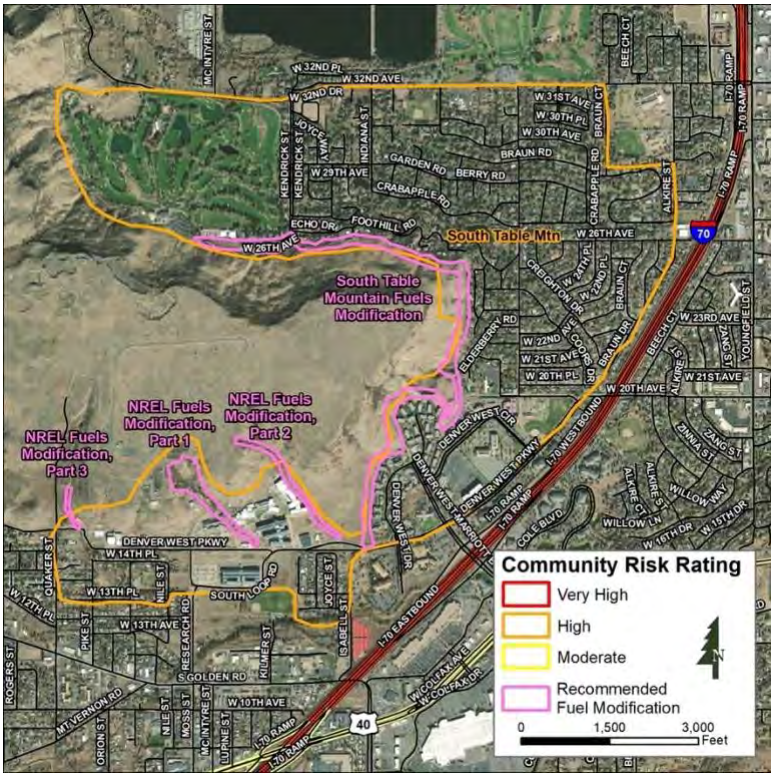
Zone Characteristics and Hazards

Mostly single-family residences on small lots. Most homes are moderate size, wood siding structures with ignition resistant trim (brick, or stone) and asphalt roofs. There are a few homes with stucco or other IR siding, however flammable fences, decks and projections are common. Very few homes (if any) have any defensible space. Most homes have flammable ornamental vegetation planted too close to structures. There are overhead powerlines in this community. Native vegetation consists primarily of heavy loads of tall grasses, cat tails and other flashy fuels. Moderate to heavy loads of shrub fuels with stringers and patches of deciduous timber are typical on the slopes below the homes. Topography is flat near the creek, but there are steep slopes directly below the homes. Roads are paved and of adequate width, but many homes are located on dead ends and cul de sacs with no alternative access and poor turnarounds for apparatus. Street signs are reflective, but address markers are inconsistent, often not reflective, or missing entirely. This community borders heavily used open space and several fires have been started by illegal camping and transients.

Recommendations

- Defensible space for homes adjacent to the open space is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Mitigation of the continuous, heavy fuel load below homes in this zone is a critical need. This project is described in the *Landscape Scale Fuels Modification* section of this report under "Other Recommendations."
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, South Table Mountain – Hazard Zone C



South Table Mountain - Hazard Zone C

Hazard Rating:	**High**
Utilities Above or Below Ground:	Above ground power lines
General Construction:	Combustible siding with mix of IR and combustible roofs
Average Lot Size:	Small
Dual Access Roads:	Yes
Road Widths, Slope and Surface:	Good surface, some steep and narrow.
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 1 mile

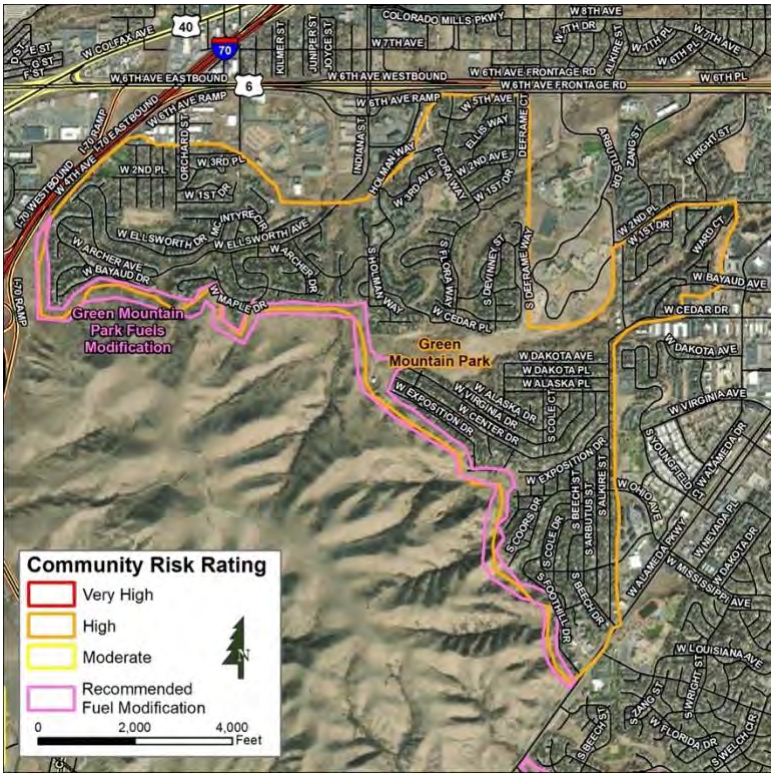
Zone Characteristics and Hazards

Residences in this zone are primarily small, single-family homes of older construction on small lots. Most are wood siding structures with a mix of wood shake and IR roofs. A few of the newer homes have at least some ignition-resistant siding. Several homes are located on ridges, mid-slope and above ravines with heavy fuel loads. Some homes have flammable outbuildings and wooden fences, stairs and decks are common. Homes on the east and north edges of Jefferson County open space exist in a continuous fuel bed and do not have any defensible space. Many homes have flammable ornamental vegetation planted too close to structures. There are overhead powerlines in this community including high tension lines with no vegetative maintenance. Native vegetation consists primarily of moderate to heavy loads of grasses and shrubs with stands of conifer and deciduous timber mixed in. Topography is steep and complex near the open space gradually becoming less steep to the east towards I-70. Radio communications in the more complex terrain is difficult. Roads are paved, but some roads and driveways are narrow, winding and steep. Although there are multiple ways in and out of this community, some homes are located on dead ends and cul de sacs with no alternative access and poor turnarounds for apparatus. Evacuation could be difficult due to steep, narrow, winding roads and possible choke points. Street signs are reflective, but address markers are inconsistent, usually not reflective, or missing entirely. This community borders heavily used open space, but a golf course does provide some break in the fuel continuity on the north side.

Recommendations

- Defensible space is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Evacuation will be difficult in this zone due to steep, narrow and winding roads and driveways. Some access roads run though moderate to heavy vegetation. Roadside fuels reduction is highly recommended wherever roads and driveways run through natural vegetation. We recommend an evacuation plan be developed to assist in the most efficient evacuation of residents from areas with difficult access. Public education will be necessary to familiarize residents with the evacuation plan. This plan should be reviewed on a regular basis to ensure its continued viability. For more information on roadside vegetative management and evacuation planning see *Appendix B, Evacuation Discussion and Recommendations*.
- Radio communication has been described as difficult in this area. In addition to equipment operating on the 800 MHz trunk frequencies we recommend establishing a VHF tactical channel frequency and equipping any apparatus responding to this zone with VHF radio equipment. Crews responding to calls in this zone should also be equipped with handheld VHF transceivers.
- Mitigation of moderate to heavy fuel loads under high tension power lines in this zone is a priority. This project is described in the *Landscape Scale Fuels Modification* section of this report under "Other Recommendations."
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Green Mountain Park – Hazard Zone D



Green Mountain Park - Hazard Zone D

Hazard Rating:	**High**
Utilities Above or Below Ground:	Above ground power lines
General Construction:	Primarily combustible siding with ignition resistant roofs
Average Lot Size:	Small
Dual Access Roads:	Yes, but see text
Road Widths, Slope and Surface:	Good surface, some steep and winding
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 1.1 miles

Zone Characteristics and Hazards

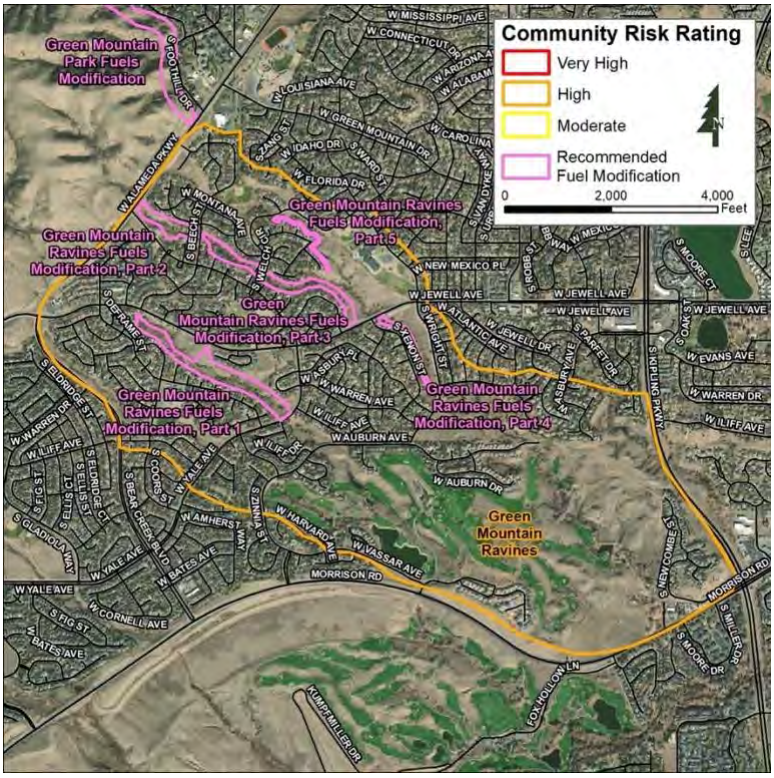
Mostly single-family residences on small lots, but there are some apartment buildings and multi-family units on the south and east sides. There is a mix of newer and older construction and the potential for more homes to be built on the north side. Most homes are moderate size, wood siding structures with ignition resistant trim (brick, or stone) and asphalt roofs. There are some homes with stucco or other IR siding, however flammable fences, decks and projections are common. Homes on the north side tend to be larger and constructed with more ignition resistant materials, where homes on the east side tend to be older, smaller and made with more combustible materials. Very few homes have any defensible space and many are located on ridges, mid-slope and above ravines with heavy fuel loads. Many homes border heavily used open space (William F. Hayden Park at Green Mountain) and native fuels extend right up to homes. Most homes have flammable ornamental vegetation planted too close to structures. There are overhead powerlines. Native vegetation consists primarily of light to moderate loads of grasses and shrubs with heavier loads of shrubs and timber in ravines. Topography is moderately sloping with ridges and ravines. Roads are paved and of adequate width, but many homes are located on dead ends and cul de sacs with no alternative access and inadequate turnarounds for large apparatus. Street signs are well marked at intersections with reflective signage, but address markers are either missing or not reflective and placement is inconsistent. This community has been threatened by many wildfires, several that were intentionally started.

Recommendations

- Defensible space for homes adjacent to the open space is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Mitigation of continuous fuels in open space bordering homes and under some power lines in this zone is an important consideration. These projects are described in the *Landscape Scale Fuels Modification* section of this report under "Other Recommendations."
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not

familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Green Mountain Ravines – Hazard Zone E



Green Mountain Ravines - Hazard Zone E

Hazard Rating:	**High**
Utilities Above or Below Ground:	Above ground power lines
General Construction:	Primarily combustible siding with IR roof types
Average Lot Size:	Small
Dual Access Roads:	Yes, see text
Road Widths, Slope and Surface:	Generally good
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 1.6 miles

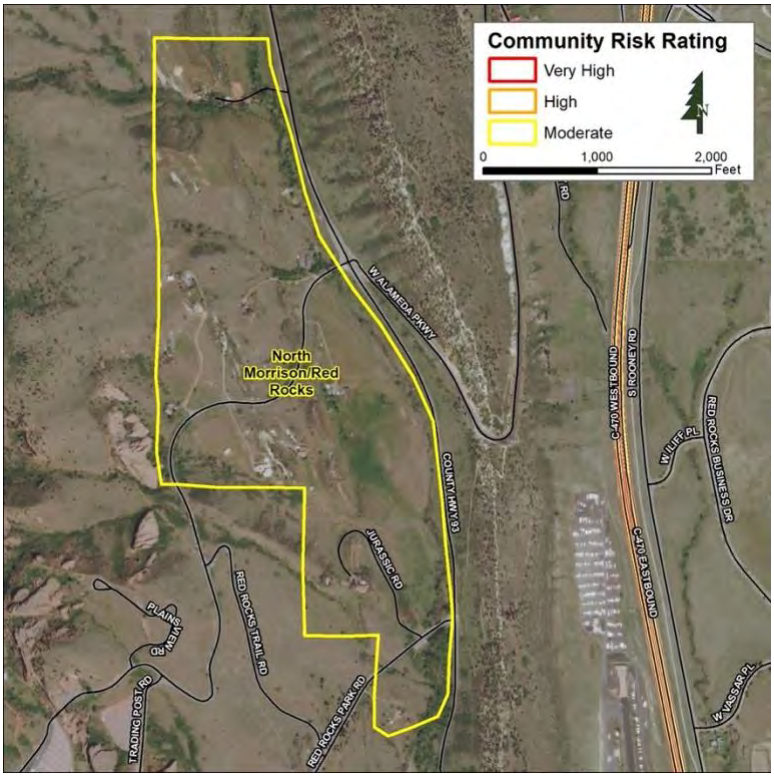
Zone Characteristics and Hazards

Mostly single-family residences on small lots, but there are also some apartment buildings and multi-family units. Most of the homes in this area are older construction. Most are small to moderate size wood siding structures with asphalt or other IR roof types. Some homes have some ignition resistant trim (brick, or stone). Flammable fences, decks and projections are common. Very few homes have any defensible space and many are located in natural fuel beds above ravines with heavy fuel loads. Large native fuel beds with deep ravines extend deeply into this community. Access to these fuel islands for fire suppression is complicated and difficult. Most homes have flammable ornamental vegetation planted too close to structures. There are overhead powerlines. Native vegetation consists primarily of light to moderate loads of grasses and shrubs with heavier loads of shrubs and timber in ravines. Topography is moderately sloping with complex ridges and ravines. Native fuels are broken on the south end of this community by a golf course and large pond. Roads are paved and of adequate width, but many homes are located on dead ends and cul de sacs with no alternative access and inadequate turnarounds for large apparatus. Street signs are well marked at intersections with reflective signage, but address markers are either missing or not reflective and placement is inconsistent. Fires have been started in this community by children playing with fire or fireworks in the open space.

Recommendations

- Defensible space for homes adjacent to the open space is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Mitigation of continuous fuels in ravines bordering homes in this zone is a priority recommendation. This project is described in the *Landscape Scale Fuels Modification* section of this report under "Other Recommendations."
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, North Morrison/Red Rocks – Hazard Zone F



North Morrison/Red Rocks - Hazard Zone F

Hazard Rating:	**Moderate**
Utilities Above or Below Ground:	Above ground power lines
General Construction:	Primarily combustible siding with IR trim and IR roofs
Average Lot Size:	Moderate to large
Dual Access Roads:	No
Road Widths, Slope and Surface:	Mixed
Water Supply:	One hydrant
Mean Distance to Fire Station:	More than 3 miles

Zone Characteristics and Hazards

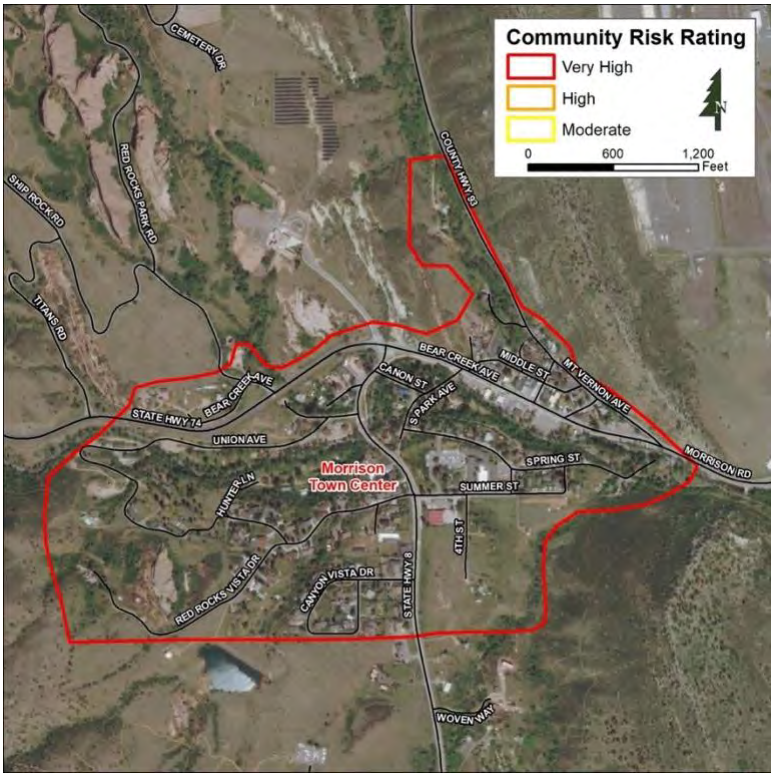
Residences in this zone are primarily large single-family homes of newer construction. They are located on large to moderate size lots and structure density is low. Some homes have ignition resistant siding and others have wood siding with decorative brick work or similar ignition resistant architectural details, however, flammable fences, decks and projections are common. Most of these homes have none or inadequate defensible space and all are located in natural fuel beds. Most homes have some flammable ornamental vegetation planted too close to structures. There are overhead powerlines. Native vegetation consists primarily of light loads of grasses and shrubs with heavier loads of shrubs and timber in stringers and patches. This community is located adjacent to Red Rocks Park and Matthews/Winters Park. These open space parks represent a continuous native fuel bed consisting mostly of light to moderate grass/shrub fuels bordering this community. Topography is low to moderately sloping with some ridges and ravines, but most ravines are not as deep and fuel loads are much lower than ravines in other communities of the study area. Roads are a mix of paved and gravel and generally of adequate width, but all these homes are located on dead ends with no alternative access. Address markers at driveways and common access points are either missing or not reflective. There is only one hydrant in this community and all the homes are a long way from any reliable dip or draft sites. They are also over three miles from the nearest fire station.

Recommendations

- Defensible space for homes adjacent to the open space is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Evacuation could be difficult in this zone due to long, narrow dirt driveways. Most of these driveways run though grass or grass/shrub fuels. Roadside fuels reduction is recommended wherever roads and driveways run through moderate to heavy loads of natural vegetation. Most access roads are one way in and out. For more information on roadside vegetative management and evacuation planning see *Appendix B, Evacuation Discussion and Recommendations*.
- There is only one hydrant in this zone making water for fire suppression a critical need. We recommend installing at least one cistern of 3,000 to 20,000 gallons on Jurassic Road near Red Rocks Park Road and two more along Red Rocks Loop Road in the western part of this zone.

- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Morrison Town Center – Hazard Zone G



Morrison Town Center - Hazard Zone G

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Above ground power, could also be some propane tanks
General Construction:	Primarily combustible siding with ignition resistant roofs
Average Lot Size:	Small
Dual Access Roads:	No, see text
Road Widths, Slope and Surface:	Mixed
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 1.6 mile

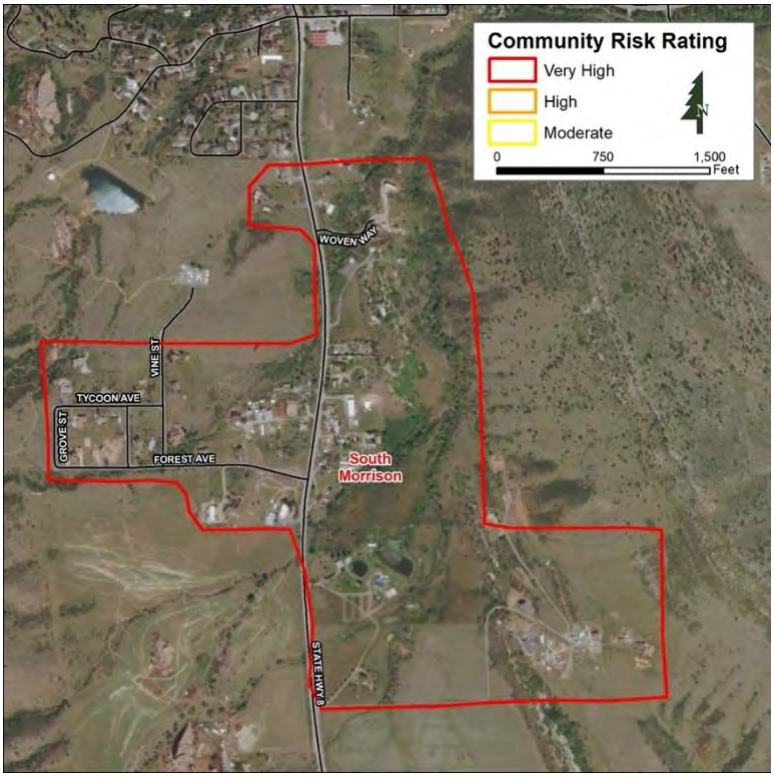
Zone Characteristics and Hazards

This is primarily a high-density community of single-family residences on small lots, but there are also some multi-family units. Most of the homes in this area are older construction and some are old enough to be considered historic properties. Most are small to moderate size wood siding structures with asphalt or other IR roof types, but there are also some structures with flammable roofs. Some homes have old and very flammable barns, outbuildings and other fuel jackpots in yards. Flammable fences, decks and projections are common. Most homes have flammable ornamental vegetation planted too close to structures. Very few homes have any defensible space and many are located in natural fuel beds, some above ravines with heavy fuel loads. Many homes are located mid-slope and on ridges. Large native fuel beds with some deep ravines extend into this community. There are many overhead powerlines including some that may be low enough to be a hazard to apparatus and there may be propane tanks on some properties. Native vegetation consists primarily of moderate to heavy loads of grasses and shrubs, including chamisa and oak brush, with heavy loads of shrubs and timber occurring in stringers, patches and ravines. Topography is steep with complex ridges and drainages. Roads are a mix of paved and gravel and some properties are accessed by gravel or dirt driveways. There are also narrow roads with tight turns. Many homes are located on dead ends that may have inadequate turnarounds for large apparatus with no alternative access. Streets are well marked at most intersections with reflective signage, but address markers are either missing or not reflective and placement is inconsistent throughout this community.

Recommendations

- Defensible space for homes is the highest priority in this zone due to small lots, high density areas and many old, very flammable structures. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Evacuation will be difficult in this zone due to narrow, circuitous roads with many dead ends. Some roads and driveways run through moderate to heavy fuel loads and some have steep grades. Roadside fuels reduction is recommended wherever roads and driveways run through moderate to heavy loads of natural vegetation. We recommend an evacuation plan be developed to assist in the most efficient evacuation of residents and visitors. Public education will be necessary to familiarize residents with the evacuation plan. This plan should be reviewed on a regular basis to ensure its continued viability. For more information on roadside vegetative management and evacuation planning see *Appendix B, Evacuation Discussion and Recommendations*.
- Mitigation of heavy fuels in ravines near homes and under some power lines in this zone is an important consideration. See "Other Recommendations" in the *Landscape Scale Fuels Modification* section of this report for more information.
- The water supply in the area near "The Fort" restaurant has been reported to be inadequate. We recommend installing at least one cistern of 3,000 to 20,000 gallons in this area.
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, South Morrison – Hazard Zone H



South Morrison - Hazard Zone H

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Above ground power lines
General Construction:	Primarily combustible siding with ignition resistant roofs
Average Lot Size:	Moderate to large
Dual Access Roads:	No
Road Widths, Slope and Surface:	Variable, see text
Water Supply:	Ponds
Mean Distance to Fire Station:	Approximately 2.2 miles

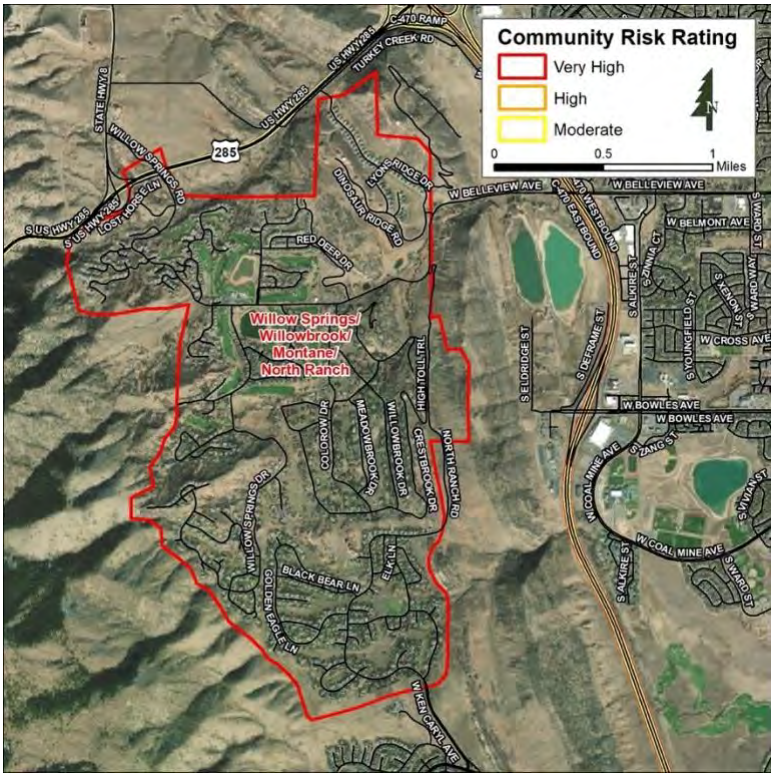
Zone Characteristics and Hazards

This area consists of clusters of homes on small to moderately sized lots and widely spaced properties on large lots. Most of the homes in this area are older construction and tend to be small to moderate size wood siding structures with asphalt or other IR roof types. There are a few larger homes built with more ignition resistant materials and there are also agricultural properties with outbuildings, equipment and other fuel jackpots in yards. Flammable fences, decks and projections are common. Most homes have flammable ornamental vegetation planted too close to structures. Few homes have adequate defensible space and most are located in natural fuel beds. Many homes are located mid-slope and some above steep slopes leading into drainages. Large native fuel beds exist throughout and adjacent to this community including Mount Falcon Open Space Park. There are many overhead powerlines. Native vegetation consists primarily of moderate to heavy loads of grasses and shrubs, including chamisa, juniper and oak brush. Conifer and deciduous timber also occur in stringers, patches and ravines. Topography is generally moderately sloping, but steeper in some areas with complex ridges and drainages. Roads are a mix of paved and gravel and some properties are accessed by gravel or dirt driveways. Most homes are located on dead end roads and long driveways with no alternative access. Only the major streets are marked at their junction with Highway 8 with reflective signage. Address markers are either missing or not reflective and placement is inconsistent throughout this community. Access to some of the larger properties is not marked at the highway. There are no hydrants in this community and only two ponds large enough for dip/draft.

Recommendations

- Most homes do not have defensible space. Defensible space is a high priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Water supply is a critical need in this zone. Although there are two ponds that may be suitable for dip/draft there are no hydrants in this zone. We recommend installing at least one cistern of 3,000 to 20,000 gallons in the western side of this zone near Forest Ave and Grove Street. Three more cisterns of 3,000 to 20,000 gallons should be spaced out north to south along Hwy 8 in locations closest to the homes.
- Mitigation of heavy fuels under some power lines in this zone is an important consideration. See "Other Recommendations" in the *Landscape Scale Fuels Modification* section of this report for more information.
- Only the major streets are marked at their junction with Highway 8 with reflective signage and address markers are either missing or not reflective throughout this zone. We recommend a program of installing reflective street signs and addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion Willow Springs to North Ranch – Hazard Zone I



Willow Springs to North Ranch - Hazard Zone I

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Mixed, see text
General Construction:	Mixed, see text
Average Lot Size:	Small to moderate, but a few larger lots
Dual Access Roads:	Mixed access
Road Widths, Slope and Surface:	Variable, see text
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately one mile

Zone Characteristics and Hazards

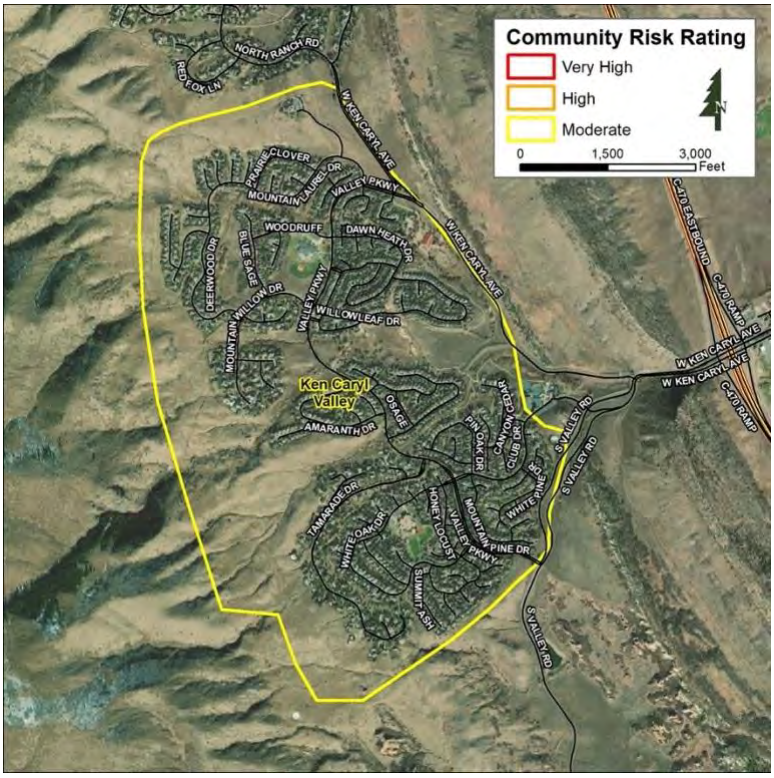
This area consists of several different neighborhoods with a large number of HOAs. Although there is a mix of construction types, most are single-family residences on small to moderate size lots. There is a mix of new and old construction and new homes are still being built on the north side, mostly in the Montane neighborhood. Most homes are moderate size with a mix of wood siding and ignition resistant trim (stucco, brick or stone) with ignition resistant roofs, however most of the older homes are largely combustible siding and wood shake roofs are common. Some of the newer homes are built with stucco or other IR siding, however flammable fences, decks and projections are common even on these. The most hazardous areas are along the entire west side, and in the Willowbrook area in the east. On the north side fuels are broken by a golf course, but islands of heavy fuels still exist. Very few homes have any defensible space and many are located on ridges, mid-slope and above ravines. Many homes border open space and native fuels extend right up to homes. Most homes have flammable ornamental vegetation planted too close to structures. There are overhead powerlines in some areas. Native vegetation consists primarily of moderate to heavy loads of grasses and shrubs. Heavier conifer fuels exist in large stringers and patches. Topography is complex and steep to moderately sloping throughout this area with the mountains to the west and the hogback to the east. Roads are paved and of adequate width, but many homes are located on dead ends and cul de sacs with no alternative access and inadequate turnarounds for large apparatus. There are also several steep, winding roads sections and driveways. Street signs inconsistent and often not reflective. Address markers are often either missing or not reflective, especially in the older areas and placement is inconsistent.

Recommendations

- Defensible space for homes is the highest priority in this zone due to complex topography and heavy shrub fuels. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- In addition to the existing projects described the *Landscape Scale Fuels Modification* section of this report, *Appendix B, Evacuation Discussion and Recommendations* describes other landscape scale fuels reduction recommendations.
- Roadside vegetative management and emergency evacuation routes are recommended for this zone. See *Appendix B, Evacuation Discussion and Recommendations* for a detailed discussion.

- Mitigation of heavy fuels under some power lines in this zone is an important consideration. See “Other Recommendations” in the *Landscape Scale Fuels Modification* section of this report for more information.
- Address markers are either not visible from the road or not reflective and placement is inconsistent. We recommend a program of installing reflective street signs and addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Ken Caryl Valley – Hazard Zone J



Ken Caryl Valley - Hazard Zone J

Hazard Rating:	**Moderate**
Utilities Above or Below Ground:	Underground
General Construction:	Combustible siding with IR roofs
Average Lot Size:	Mostly small, but larger lots on the SW side
Dual Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good
Water Supply:	Hydrants
Mean Distance to Fire Station:	2 miles

Zone Characteristics and Hazards

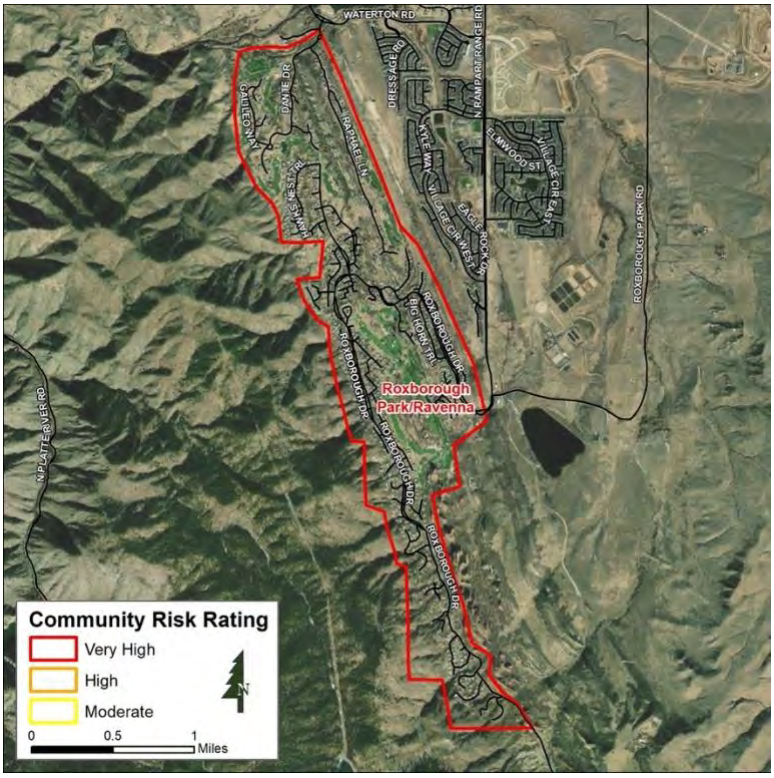
Residences in this zone are primarily small to moderate size single-family homes of newer construction. Most homes are on small lots and clustered tightly together, however larger homes on large lots exist in the southwest corner of this community. Some homes have decorative brick work or similar ignition resistant architectural details however, flammable siding is dominant. Many homes also have flammable decks, and projections. Few homes have adequate defensible space and some are located on ridges, mid-slope and above ravines. Many homes border open space and native fuels extend up to homes. Most homes have flammable ornamental vegetation planted too close to structures. Native vegetation consists primarily of light to moderate loads of grasses with shrubs and timber fuels in stringers and patches, often along drainages. Topography is low to moderately sloping throughout this area with steeper slopes to the west and the Dinosaur Ridge Hogback to the east. Several drainages run from the foothills into this community, but in general they are not as steep and fuels are not as heavy as other communities in the study area. Roads are paved and of adequate width, but many homes are located on dead ends and cul de sacs accessed by loops and circles. Although this community can also be accessed by North Ranch Road, the primary access from C470 could become a choke point for evacuation and access. Address markers are often not reflective and placement is inconsistent.

Recommendations

- Defensible space for homes is the highest priority in this zone. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- In addition to the existing fuels mitigation projects for this zone described the *Landscape Scale Fuels Modification* section of this report, *Appendix B, Evacuation Discussion and Recommendations* describes other landscape scale fuels reduction recommendations.
- Roadside vegetative management and emergency evacuation routes are recommended for this zone. See *Appendix B, Evacuation Discussion and Recommendations* for a detailed discussion.
- Address markers are either not visible from the road or not reflective and placement is inconsistent. We recommend a program of installing reflective street signs and addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district

responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Roxborough Park/Ravenna – Hazard Zone K



Roxborough Park/Ravenna - Hazard Zone K

Hazard Rating:	**Very High**
Utilities Above or Below Ground:	Underground
General Construction:	Mixed
Average Lot Size:	Small to Moderate
Dual Access Roads:	No
Road Widths, Slope and Surface:	Mostly paved, but narrow and steep sections
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 2.6 miles

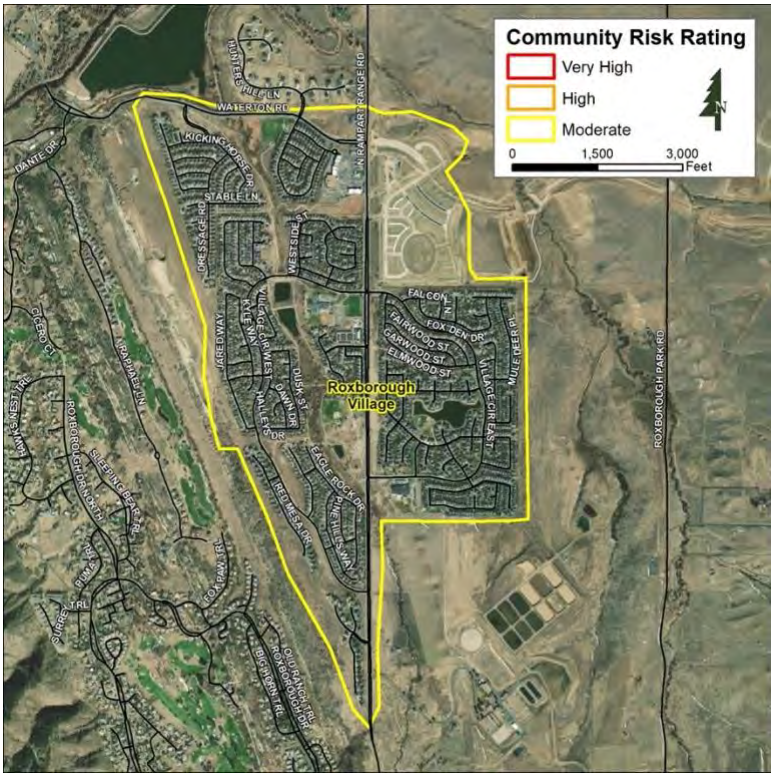
Zone Characteristics and Hazards

Residences in this zone are primarily moderate to large single-family homes of newer construction. Most homes are on small to moderate sized lots and although there are some large lots, density is high. Many homes have decorative brick work or similar ignition resistant architectural details however, many still have some flammable siding. Many homes also have flammable decks, projections and/or fences. Although fuels are broken by golf courses in the north and central parts of this community, islands of heavy shrub fuels still exist. Considering this community is bordered by steep slopes and heavy loads of conifer fuels in the Pike National Forest to the west, ember cast could start fires throughout the oak brush and grass fuels in this community despite the breaks provided by the golf courses. Very few homes have adequate defensible space and many are located on ridges (including the top of the Dinosaur Ridge Hogback), mid-slope and above ravines. Most homes have flammable ornamental and native vegetation too close to structures. Moderate to heavy loads of shrub fuels exist throughout this community even near access roads and in medians. The entire area is bordered by heavier conifer fuels and steep slopes to the west. Topography is complex and steep to moderately sloping with the mountains to the west and the Dinosaur Ridge Hogback on the east side. Roads are paved, but narrow, steep and winding in sections. Many homes are located on dead ends and cul de sacs with no alternative access. The single gated entrance and narrow roads will complicate evacuation. Although there is an emergency evacuation route running from the southern end of this community to C-67 if the fire was coming from the west burning in the heavy timber of the Pike this would be a risky route. See *Appendix B, Evacuation Discussion and Recommendations* for more information regarding evacuation from this community. Address markers are often not reflective and placement is inconsistent. Despite newer, more ignition resistant construction materials the combination of heavy fuels, steep terrain and difficult access/evacuation make this one of the most hazardous communities in the study area.

Recommendations

- Defensible space for homes is the highest priority in this zone due to dead ends, steep winding roads, complex topography and heavy fuels. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Evacuation will be difficult in this zone due to narrow, circuitous roads with many dead ends. Some roads and driveways run through moderate to heavy fuel loads and there are steep grades. Roadside fuels reduction is recommended wherever roads and driveways run through moderate to heavy loads of natural vegetation. We recommend an evacuation plan be developed to assist in the most efficient evacuation of residents and visitors. Public education will be necessary to familiarize residents with the evacuation plan. This plan should be reviewed on a regular basis to ensure its continued viability. For more information on roadside vegetative management and evacuation planning see *Appendix B, Evacuation Discussion and Recommendations*.
- Roadside vegetative management and emergency evacuation routes are recommended for this zone. See *Appendix B, Evacuation Discussion and Recommendations* for a detailed discussion.
- In addition to the fuels modification recommendations in Appendix B high priority existing projects are described the *Landscape Scale Fuels Modification* section of this report.
- Address markers are either not visible from the road or not reflective and placement is inconsistent. We recommend a program of installing reflective street signs and addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

Structural Ignitability Discussion, Roxborough Village – Hazard Zone L



Roxborough Village - Hazard Zone L

Hazard Rating:	**Moderate**
Utilities Above or Below Ground:	Underground
General Construction:	Combustible siding with IR roofs
Average Lot Size:	Small
Dual Access Roads:	Yes
Road Widths, Slope and Surface:	Generally good
Water Supply:	Hydrants
Mean Distance to Fire Station:	Approximately 1.8 miles

Zone Characteristics and Hazards

Residences in this zone are primarily small to moderate size single-family homes on small lots. This is a high-density community. Almost all these homes are newer construction and construction is still ongoing. Many homes have some ignition resistant trim, but flammable siding is still dominant. Most also have flammable decks, projections and/or fencing. Although native fuels are light to non-existent between many homes, most still have flammable ornamental vegetation planted too close to the structure. Native vegetation consists primarily of light to moderate loads of grasses and low growing shrubs, although some heavier fuels exist in isolated patches. Native fuels are further broken by ponds and irrigated fields. Topography is flat to gently rolling although slopes leading up to the Dinosaur Ridge Hogback to the east of this community are steeper. Roads are paved and of adequate width. Although access is generally good, many homes are located on dead ends and cul de sacs. Address markers are usually not reflective; however, placement is usually over the garage door and is reasonably consistent throughout this community.

Recommendations

- Defensible space for homes is the highest priority in this zone due to small lots, high density areas and flammable construction materials. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Along with defensible space it is highest priority for homes in this zone to be fire hardened to the greatest extent practical. See *Appendix A, Home Ignition Zone Recommendations* for details.
- Address markers are either missing or not reflective throughout this zone and placement is inconsistent. We recommend a program of installing reflective addressing that can be read at the street to assist responders in locating properties during an emergency. This can be especially critical during a large fire event for out of district responders who are not familiar with the area. For more information see *Appendix B, Evacuation Discussion and Recommendations*.

GENERAL RECOMMENDATIONS

The two most important recommendations in this report are;
1) to incorporate defensible space techniques and ignition resistant construction in future development plans, and 2) for existing structures to be fire hardened to the greatest extent practical. Detailed information on achieving these goals is available on the WMI and *Appendix A, Home Ignition Zone Recommendations*.

The following general measures listed below should be practiced throughout the study area. Some of these recommendations may already be in place in some areas.

1. Clean roofs and gutters at least twice a year. It is vital to remove pine needles and other flammable litter from the roof.
2. Don't store firewood or other combustibles under decks, stairs, or wooden projections.
3. Maintain an irrigated greenbelt or other non-combustible ground cover around buildings.
4. Maintain and clean spark arresters on any chimneys.
5. Connect and have available a minimum of 50 feet of garden hose near all buildings to extinguish small fires before they spread. For large buildings, two or more hoses may be required to provide adequate coverage.
6. Trees, large shrubs, and other vegetation along driveways should be pruned as necessary to maintain a minimum of 15 feet of vertical clearance for emergency vehicle access. This recommendation is for both conifers and deciduous trees.
7. For driveways longer than 150 feet, a cleared turnaround for fire apparatus should be provided. Turnarounds may consist of a 96-foot circle, 60-foot "Y", or 120-foot "Hammerhead" described in the 2018 International Fire Code.[i] Driveways should be at least 20 feet wide where possible.
8. Maintain the defensible space around buildings by:
    a. Mowing grass and weeds to a height of four inches or less
    b. Removing any branches overhanging roofs or chimneys.
    c. Removing all trash, debris, and cuttings from the defensible space. Debris and cuttings should be removed entirely from the area and never dumped into adjacent wildlands or vacant lots.

It is essential to remember that fire mitigation is not a one-time job. Defensible space should be maintained year-round, and reducing structural ignitibility is an ongoing process. For more information, please see *Appendix A, Home Ignition Zone Recommendations,* and the WMI.

The WMI should be reviewed and continuously updated to ensure the information regarding hazards and recommended solutions and other important information presented there stays current.

ACCESS/EGRESS ROUTES & EVACUATION

The main corridors through the study area are I-70, US-6/US-40, US-285, C-470, and CR-8. Although there are several subdivisions with homes located on dead ends and cul-de-sacs, the communities east of C-470/I-70 have reasonable access to at least one of these major corridors. Communities where evacuation is more complex include South Table Mountain, Willow Springs to North Ranch, Ken Caryl Valley, and Roxborough/Ravenna. Time Until Fire Arrival (TUFA) has been modeled for six alternate routes through three of these communities.

TUFA is a tool that combines GIS spatial analysis with rate of spread modeling. It calculates the time for a wildfire to arrive at the selected points of interest. TUFA uses a fixed wind and moisture profile but adjusts for slope, aspect, and fuel models to derive a rate of spread for every point on the landscape. Since it isn't possible to predict precisely where an ignition resulting in a significant wildfire will occur, this is a valuable way to analyze multiple areas on the landscape. In the case of this analysis, the time it would take fire to impact the egress routes modeled from ignitions occurring in wildland fuels within and adjacent to the study area. Detailed results are available in *Appendix B, Evacuation Discussion and Recommendations* of this report, and on the Web Map Interface (WMI). This information should be used to aid evacuation planning for the district.

Additional information regarding evacuation in the Roxborough/Ravenna community can be found in the *Douglas County All-Hazards Evacuation, Alert and Warnings Annex of the Douglas County Comprehensive Emergency Management Plan*[ii], and the *Roxborough Park Wildfire Evacuation Guide.*

Evacuation recommendations, both general and specific, are discussed in detail in *Appendix B, Evacuation Discussion and Recommendations*.

LANDSCAPE SCALE FUELS MODIFICATION

When most people think of a fuelbreak they envision a line, usually 10 to 30 feet wide, where all vegetation has been removed to mineral soil; however, the concept of a fuelbreak can describe any area where fuels have been strategically manipulated to reduce the spread and intensity of wildfire. Since the concept of a fuelbreak is more nebulous than the specific definitions of "fireline" and "firebreak" as used by wildland firefighters, the effectiveness of fuelbreaks has been the subject of debate among fire scientists and forest managers for many years. The concept of a "shaded fuelbreak" is most applicable to forested areas. Unlike firebreaks, which imply removing all vegetation down to mineral soil, shaded fuelbreaks are created by altering the surface fuels, increasing the height to base of the live crown, and opening the canopy by removing trees. It is critical to understand the purpose of a fuelbreak is not to stop a fire but to reduce intensity and rate of spread to give firefighters a higher probability of successfully attacking the fire and protecting exposures. Once installed, fuelbreaks require regular maintenance to ensure they will continue to alter the behavior of fire entering the treated area. Some of the shaded fuelbreak creation and maintenance concepts may also apply to shrublands, depending on the type, canopy height, and density of shrubs.

There is much discussion as to how far fuels modifications must extend for fuelbreaks to be effective. In this report, when distances are given, they are intended as minimums. Depending on fuels and topography, more extensive treatment areas may be necessary. The recommendations in this report are general. The specific design of any fuelbreak should be referred to qualified experts familiar with both the vegetation and fire behavior of the area. Standards and guidance provided by the Colorado State Forest Service should be a primary source for this information.

Existing Projects and Recommendations

The 2015 *Willow Springs Open Space Forest Stewardship Plan*[iii] identified several fuels modification projects recommended to reduce wildfire threat to the adjacent residential communities. Willow Springs Open Space covers 830 acres primarily to the west of private residences. Recommendations included the following:

- Creation of a 15-acre shaded fuelbreak on the southwest corner of the property, which could be used to extend an existing fuelbreak created by Ken Caryl Ranch and the ridgeline.[iv] The fuelbreak recommended is to be at least 300 feet wide and follow the property boundary in the forested section at the southwest corner.
- Oak brush management along the eastern border of the Willow Springs Open Space (WSOS) closest to private residences. Mosaic cutting in five management units on 51.2 acres was recommended to reduce fuels continuity to homes.[v]
- General thinning of Douglas fir stands throughout the open space property to reduce the basal area to 75-85 square feet per acre, targeting sick, injured, dead, or dying trees.[vi]

Although all three of these projects affect fire behavior in large continuous fuelbeds west of residences, the recommended oak brush management should be the highest priority for he reduction of wildfire hazards to the community. If cooperation could be obtained from the Ken Caryl Ranch Master Association for linking and maintaining the fuelbreak in Ken Caryl Ranch

with the proposed Willow Springs Open Space fuelbreak, the 15-acre fuelbreak recommended for the southwest corner of Willow Springs Open Space should be the next highest priority.

According to the 2018 *Ken-Caryl Ranch Community and Open Space Wildfire Hazard Mitigation Plan*, fuels reduction recommended in the 2008 and 2015 management plans has been completed in the Tincup, Shaffer, and Beacon Hill areas of Ken Caryl Ranch Open Space.[vii] Maintenance of fuelbreak and thinning operations in the Beacon Hill, Shaffers, Tincup, and Docmann Gulch areas was recommended in the 2018 Ken-Caryl mitigation plan and is also recommended by this study.

The 2018 Ken-Caryl plan recognizes the importance of defensible space, which is the highest priority recommendation in this study.[viii] Although much of the information in the Ken-Caryl plan is valuable, defensible space standards have changed since 2018. For the most current recommendations, see *Appendix A, Home Ignition Zone Recommendations* of this report, and the WMI.

The 2011 Douglas County CWPP proposed a one-half mile wide fuelbreak on each side of the USFS South Platte Ranger District boundary.[ix] Although this is a worthwhile proposal to reduce intensity, ember cast, and the potential for crown fire development along the forest border, this project requires agreement and cooperation of federal and private property owners. It includes roadless areas that fall under NEPA requirements. Although we recommend continuing to pursue the necessary agreements for design and implementation, we consider this a long-term forest management goal that will require significant effort and refinement to verify its feasibility. We, therefore, consider this recommendation to be a lower priority than treatments providing more immediate hazard reduction to residents and homes.

The 2020 Roxborough Park Community Wildfire Protection Plan contains general recommendations for shaded fuelbreaks in Zone 2 (5 to 30 feet from homes) and forest health thinning for Zone 3 (30 feet to the boundary of the property)[x]. These are home ignition zone recommendations rather than landscape-scale fuel modification recommendations. Home ignition zone recommendations are discussed in Appendix A of this report.

Other Recommendations

- Homes bordering the south side of the Clear Creek corridor open space are located on short but steep slopes above heavy fuels (see Figure 2). We recommend WMFR work with open space land managers and property owners to mechanically thin fuels below homes for 100 feet from the property line or the bottom of the slope, whichever distance is less. This treatment will be most effective when combined with linked defensible space treatments. Grasses should be mowed to a height of no more than four inches and flammable shrubs removed. Trees should be limbed to a height of eight feet or 1/3 the tree height for trees less than 24 feet tall. Dead, dying, diseased, and damaged trees should also be removed. This treatment affects homes between the open space and the following streets, W. 38th Drive, W. 39th Place, W. 40th Avenue, and W. 41st Avenue.

Figure 2, Fuels below homes along Clear Creek

- Grass and shrub fuels should be treated for a distance of 100 feet from the property line into the South Table Mountain Open Space for homes bordering the north and east sides of the open space property. This recommendation includes homes on W. 26th Avenue, Foothill Road, Foothill Lane, Old Quarry Road, Elderberry Road, Denver West Road, Denver West Court, and Denver West Circle. Grasses should be mowed to a height of no more than four inches. Shrub fuels should be reduced to clusters no larger than 40 feet in any direction with a spacing between groupings of at least 2 ½ times the height of the tallest remaining shrubs. There is no significant tree canopy to be of concern in the recommended treatment area. In areas where short grasses are the dominant fuel, prescribed fire should be considered as a treatment method. Fuels reduction in the open space will be most effective when combined with linked defensible space treatments. We recommend WMFR collaborate with individual property owners and open space land managers to create the most effective treatment plan.
- Grass and shrub fuels should be treated for a distance of 100 feet from the property line into W. F. Hayden Green Mountain Park for homes bordering the north and east sides of the open space property. This recommendation includes all the homes in the Green Mountain Park – Hazard Zone D community bordering the open space property. Grasses should be mowed to a height of no more than four inches. Shrub fuels should be reduced to clusters no larger than 40 feet in any direction with a spacing between groupings of at least 2 ½ times the height of the tallest remaining shrubs. There is no significant tree canopy to be of concern in the open space area; however, there are substantial ornamental plantings near homes and in some drainages that should be treated as described in the

home ignition zone recommendations. In areas where short grasses are the dominant fuel, prescribed fire should be considered as a treatment method (Figure 3). This treatment will be most effective when combined with linked defensible space treatments. We recommend WMFR work with individual property owners and open space land managers to create the most effective treatment prescription.

Figure 3, Grass fuels bordering homes in Green Mountain Park

- As described in the *Structural Ignitability Discussion, Green Mountain Ravines – Hazard Zone E* section above, large native fuel beds with deep ravines extend deeply into this community (Figure 4). Access to these fuel islands for fire suppression is complicated and difficult. We, therefore, recommend that where these ravines are located on HOA or public land, WMFR work with the appropriate land managers and individual property owners of homes located above the ravines to create linked defensible spaces and treat native fuels for a distance of 100 feet from the property line or to the edge of ravines where heavy fuel loads exist. Grasses should be mowed to a height of no more than four inches. Shrub fuels should be reduced to clusters no larger than 40 feet in any direction with a spacing between groupings of at least 2 ½ times the height of the tallest remaining shrubs. Trees should be limbed to a height of eight feet or 1/3 the tree height for trees less than 24 feet tall. Dead, dying, diseased, and damaged trees should be removed.

Figure 4, Fuels in ravines bordering homes in Green Mountain Ravines

- In addition to the existing projects described earlier, *Appendix B, Evacuation Discussion and Recommendations* describes other landscape-scale fuels reduction recommendations in the following communities: Willow Springs to North Ranch, Ken Caryl Valley, and Roxborough Park/Ravenna. A detailed discussion of these recommendations can be found in Appendix B.
- Any high-tension power lines such as the ones shown in Figure 5 should have the following vegetation management implemented and maintained for a distance of at least 15 feet to either side of the edges of the pole/tower structure or to the edge of the power line easement. At ground level, flammable materials, including not only live vegetation but also ground litter, duff, and dead vegetation that will propagate fire, should be removed. From ground level to eight feet, brush and grasses higher than six inches should be cut, and any live trees should be limbed to a height of 8 feet or 1/3 of the tree height for trees less than 24 feet. From 8 feet to the horizontal plane of the highest conductor attachment, any dead or diseased limbs should be removed from live trees and any diseased, dying, or dead trees removed in their entirety. The Colorado State Forest Service should evaluate the power line cut for any further specific treatments that may be necessary.
- All the existing and recommended treatment units should be maintained in accordance with standards provided by the Colorado State Forest Service and should be reevaluated on an annual basis. Progress should be captured and updated in the WMI.

Figure 5, Fuels under power lines in Green Mountain Park

Prescribed Fire Use

In some parts of the study area, large native fuel beds exist adjacent to residential structures where the dominant native vegetation is grass or light loads of discontinuous grass/shrub. In these areas, prescribed fire could be a valuable tool to lower rate of spread, lessen ember cast, remove hazardous accumulations of dead surface fuels and reduce regrowth. Short-duration burns will be preferable in most communities to minimize the effects of smoke and embers on residents. This tactic could be especially useful in the South Table Mountain, Green Mountain Park, and Green Mountain Ravines communities. Prescribed fire use also provides excellent training opportunities for local fire departments in partnership with Open Space agencies.

The use of fire to eliminate accumulations of undesirable and hazardous fuel loads is an ancient technique used by indigenous peoples all over the world where uncontrolled fire is a risk to life and property. Although mechanical thinning has traditionally been the preferred method of fuels treatment in the American WUI, there is an increased interest in the use of small prescribed fires as a management tool. The history of this practice in the American Southwest is discussed in a 2020 article published in the Proceedings of the National Academy of Sciences of the United States available at the following link: https://www.pnas.org/content/118/4/e2018733118 .

Areas of Special Interest Recommendations

Introduction

Areas of Special Interest (ASI) are non-residential areas considered to contain physical properties or values likely to have a considerable effect on people, property, the economy, or the environment of the study area in the event of damage from a significant wildfire. The following ASIs were identified in the study area:

- Red Rocks Park and Amphitheater
- State, county and city parks and open space
- Lockheed Martin campus
- National Renewable Energy Labs (NREL)

Red Rocks Park and Amphitheater

The study area is home to the Red Rocks Park and Amphitheatre, a live music and events center located on 738 acres, owned and operated by the City and County of Denver. WMFR provides fire protection for the entire property situated between the North Morrison and Morrison Town Center communities. There is a 1.4-mile hiking trail located at the event center, as well as a grill, trading post, art gallery, and several parking lots surrounding the amphitheater. Although the natural amphitheater and the seating area are entirely sandstone and reinforced steel, large grass/shrub fuelbeds have been left undisturbed to provide a natural setting. For the latest and most complete information regarding this ASI, please visit the WMI.

Figure 6, Red Rocks Amphitheatre

Recommendations

1. We recognize the importance of maintaining the park in a natural state. However, even though the amphitheater itself and most of the support buildings are ignition resistant, there are areas where access roads run through significant fuel beds. The following vegetation management recommendations should be applied to all roads in the park. The highest priority is Red Rocks Park Road, which is the primary access exiting the park to the north and south.

- Fuels should be monitored along access roads to ensure flammable vegetation does not compromise their use during wildfire events.
- Limbing and thinning should be conducted in any section where fuels are found near the road.
- Hazardous trees and shrubs should be removed within 10 feet of the roadway, and any grasses mowed to a height of no more than four inches.
- Trees should be trimmed to at least a height of eight feet for trees 24 feet or taller and 1/3 the tree height for smaller trees within 30 feet of the roadway to prevent surface fires from laddering into the canopy near the road.

2. Defensible space should be provided and maintained for any permanent critical infrastructure to prevent loss and provide safer access to firefighters.

State, County and City Parks and Open Space

The State of Colorado, Jefferson County Open Space, and the City of Lakewood own and maintain several parks, public events venues, and visitor attractions in and adjacent to the study area. The following is a list of the largest of these:

- South Table Mountain Park (Jefferson County Open Space) – 1,484 acres. 14.2 miles of trails, but the only infrastructure is related to the Colorado State Police driving track). Grass and shrub fuels, some steep topography. Includes conservation easements from the State of Colorado and the U.S. Department of Energy. Some private land inholdings but this land is undeveloped.
- William F. Hayden Green Mountain Park (City of Lakewood) – 2,400 acres. Trails and parking lots, but no significant infrastructure. Grass and shrub fuels with complex topography.
- Matthews/Winters Park (Jefferson County Open Space) – 2,461 acres. 11.9 miles of trails. Open to mountain biking, hiking, and horses. Includes a significant part of the Dinosaur Ridge Hogback. Facilities include bathrooms, picnic areas, and the Dinosaur Ridge Visitors Center. Most of these buildings have some ignition-resistant construction. No homes or critical infrastructure are located in the park; however, this park surrounds the North Morrison community on the north, east and west sides. It also abuts Red Rocks Park. Grass and shrub fuels are discontinuous.
- Mount Falcon Park (Jefferson County Open Space) – 2,253 acres. 12.2 miles of trails. The Morrison trailhead is located in the Morrison Town Center community. Trails and parking lots, but no significant infrastructure. Fuels vary from grasses and shrubs at the lower elevations to timber in drainages and at higher elevations. Topography is steep and complex.
- Mount Glennon (Jefferson County Open Space) – 327 acres of open space located east of the Morrison Town Center and South Morrison communities. Completely undeveloped; no trails, facilities, or parking lots. Steep slopes and rocky cliffs. Grass and shrub fuels.
- South Valley Park (Jefferson County Open Space) – 995 acres with 7.7 trail miles located south of the Ken Caryl Valley community. Open to mountain biking, hiking, and horses. The entire northwest section is closed to the public for resource protection. Trails, parking lots, restrooms, and picnic areas, but no significant infrastructure. Mostly grass fuels, but timber and shrubs in stringers and patches. Topography is generally flat, with some steep hills on the west side near Dear Creek Canyon.
- Roxborough State Park (Colorado State Parks) – 4,000 acres with approximately 14 miles of trails located south of the Ravenna/Roxborough Park community. Roxborough State Park also surrounds the southern end of that community. Open to hiking only. Visitor's center and one parking lot for the single entrance road. No other infrastructure. Moderate to heavy loads of oak brush and grass fuels. Complex, steep topography. Although West Metro provides fire protection, the park has its own fuels management plan, which includes prescribed fire in the grasslands and oak brush thinning.

Figure 7, William F. Hayden Park at Green Mountain, Jefferson County Open Space

Recommendations

- Some of the parks listed above have permanent structures. However, these are day-use facilities such as visitor's centers, restrooms, and picnic shelters. There are no residences or guest lodging at these parks, and none are open for camping or overnight use. Defensible space is recommended for any permanent structures, but these sites are a low priority for mitigation. These sites should be straightforward to close and evacuate in the event of a nearby fire and should not represent a threat to life safety.
- Most of these parks are high-use areas, and a public education campaign to raise awareness regarding wildfire danger and promote fire safe use of these public properties should be an ongoing project. These properties are kept in a natural condition,, and no other recommendations regarding fuels, water supply, or operational factors are applicable.

Lockheed Martin Waterton Campus

Lockheed Martin owns and operates a large parcel of land north of the mouth of Waterton Canyon. The company has invested over $350M to construct a new "Gateway Center" on this property. Fire protection for the Lockheed Martin campus is provided by South Metro Fire Rescue Authority (SMFR) and is therefore outside the scope of this study. WMFR does, however, have a mutual aid agreement with SMFR. We recommend joint planning and training with SMFR to ensure a seamless response for this high-value, complex property.

National Renewable Energy Laboratory (NREL)

The US Department of Energy owns and operates the NREL property in the WMFR response area south of the South Table Mountain Open Space Park. This campus includes NREL's administrative offices, education center, and most of its research laboratories.
Most buildings on the NREL campus are of ignition-resistant construction. Access is excellent throughout the campus, and evacuation shouldn't be an issue in the event of a wildland fire.

Topography is relatively flat on the southern side near Denver West Parkway; however, it becomes steeper to the north near the open space boundary. The Colorado State Patrol maintains a driving training track in the conservation easement to the northwest of the NREL campus that could be a source of ignition. Although most of the fuels near NREL buildings are light to moderate loads of grass and grass/shrub, there are heavier shrub and timber fuels running in stringers from the mesa where the driving track is located.

Recommendations

- Defensible space should be provided and maintained for all buildings within 100 feet of natural fuels to prevent loss and provide safer access to firefighters. The defensible space standards in *Appendix A, Home Ignition Zone Recommendations,* are applicable.
- We recommend WMFR work with NREL to develop and maintain a fuels management program to interrupt the continuity of shrub fuels in the drainages running from the steeper terrain north of NREL buildings.

CONCLUSION

The scientific analysis performed during the preparation of this report shows significant potential for wildfires to affect the study area. Due to high numbers of residents and visitors, fires in this area have considerable potential for loss of life and damage to property. Several fires have been started in open space areas by transients and children playing with fire or fireworks. The following summary is a distillation of what we think should be the highest priority actions to preserve life and property:

- Individual property owners must realize the survival of their homes will rely heavily on their ability and willingness to create defensible space and harden their structures to the greatest extent practical against ignitability from embers and firebrands.
- WMFR, Jefferson County, Douglas County, and CSFS should support mitigation efforts of residents by advising and assisting those efforts wherever possible and by ensuring any existing statutes regarding fire hazard abatement are enforced.
- Existing fuels mitigations projects should be completed and combined with the projects recommended in this report.
- Coordination of fuels mitigation efforts between WMFR, CSFS, USFS (Pike National Forest), Jefferson County, Douglas County, Colorado State Parks (Roxborough Park fuels management), and neighboring fire departments will be needed to produce the most efficient fuels management in the study area. The WMI should be utilized to assist in coordinating and tracking the evolution of fuels management projects.
- Recommendations to monitor and remove dangerous fuel loads along primary and alternative access roads that could threaten access and egress should be a high priority. These can be found in *Appendix B, Evacuation Discussion and Recommendations*. Mitigation efforts must be ongoing to be effective.
- Some areas have limited water for fire suppression. The development of an adequate water supply for fire suppression is a critical need in these areas.
- Efforts to improve addressing and street markers will be needed along with pre-planning and public awareness of evacuation routes to prevent bottlenecking and delays in evacuation and responder access during a fire.

GRANT RESOURCES

One of the biggest obstacles to overcome when trying to implement CWPP recommendations and wildfire mitigation projects is funding. A certified CWPP opens a multitude of funding sources to complete work outlined in the plan. For many mitigation projects, federal, state and county funds are available to begin work. The list below is not exhaustive, but rather serves as a starting point for the most commonly available sources of funding and outreach.

Federal Emergency Management Agency (FEMA)

- **Assistance to Firefighters Grant Program**
  - Purpose: to improve firefighting operations, purchase firefighting vehicles, equipment and personal protective equipment; fund fire prevention programs; and establish wellness and fitness programs.
  - Necessary information includes a DUNS number, Tax ID number and Central Contractor Registration
  - **https://www.fema.gov/welcome-assistance-firefighters-grant-program**
- **SAFER: Staffing for Adequate Fire and Emergency Response**
  - Purpose: to provide funding directly to fire departments and volunteer firefighter interest organizations in order to help them increase the number of trained, "front line" firefighters available in their communities. The goal of SAFER is to enhance the ability of local fire departments to comply with staffing, response and operational standards established by NFPA and OSHA.
  - **https://www.fema.gov/staffing-adequate-fire-emergency-response-grants**
- **Fire Prevention and Safety Grants (FP&S)**
  - Purpose: FP&S Grants are part of the Assistance to Firefighters Grants and are under the purview of the Grant Programs Directorate in FEMA. Their purpose is to support projects that enhance the safety of the public and firefighters from fire and related hazards.
  - **https://www.fema.gov/fire-prevention-safety-grants**
- **Hazard Mitigation Assistance Grant Program (HMA)**
  - Purpose: to provide grants to state and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The goal of HMA is to reduce the loss of life and property due to natural disasters and enable mitigation measures to be implemented during the immediate recovery from a disaster.
  - **https://www.fema.gov/media-library-data/1441133724295-0933f57e7ad4618d89debd1ddc6562d3/FEMA_HMA_Grants_4pg_2015_508.pdf**

- **Pre-Disaster Mitigation Grant Program (PDM)**
  - Purpose: to provide funds to states, territories, Tribal governments, communities, and universities for hazard-mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces the overall risks to the population and structures.
  - **https://www.fema.gov/pre-disaster-mitigation-grant-program**

Firewise Communities

  - Purpose: a multi-agency organization designed to increase education of homeowners, community leaders, developers, and others regarding the Wildland-Urban Interface and the actions they can take to reduce fire risk to protect lives, property and ecosystems.
  - **http://www.firewise.org**

National Volunteer Fire Council

  - Purpose: to support volunteer fire protection districts. Includes both federal and non-federal funding options and grant writing assistance.
  - **http://www.nvfc.org/**

National Resources Conservation Service Emergency Watershed Protection Program

  - Purpose: to undertake emergency measures including the purchase of flood plain easements for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed.
  - **https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ewp/**

USFS Cooperative Forestry Assistance

  - Purpose: to assist in the advancement of forest resources management, the control of insects and diseases affecting trees and forests, the improvement and maintenance of fish and wildlife habitat, and the planning and conduct of urban and community forestry programs.
  - **https://www.fs.fed.us/spf/coop/programs/loa/**

REFERENCES AND NOTES

[i] https://codes.iccsafe.org/content/IFC2018/APPENDIX-D-FIRE-APPARATUS-ACCESS-ROADS
[ii] *Douglas County All-Hazards Evacuation, Alert and Warning Annex, An Annex of the Douglas County Comprehensive Emergency Management Plan* (Douglas County Office of Emergency Management, Douglas County Colorado, 2019), Page 153-154.
[iii] Trevor Seck and Dan Allen, *Forest Stewardship Plan, Willow Springs Open Space,* (Colorado State Forest Service, Golden Colorado, 2015).
[iv] Ibid, Page 29-30.
[v] Ibid, Page 31-32.
[vi] Ibid, Page 32-33.
[vii] *Wildfire Hazard Mitigation Plan, Ken-Caryl Ranch Community and Open Space,* (Colorado State Forest Service, Golden Colorado, 2018). Page 18.
[viii] Ibid, Page 12.
[ix] *Community Wildfire Protection Plan, Douglas County Colorado*, (Douglas County Colorado, 2011). Page 290.
[x] *Community Wildfire Protection Plan, Roxborough Park Colorado,* (Roxborough Park Foundation Fire Mitigation Committee, 2020) Page 38.

Appendix A Home Ignition Zone Recommendations

Purpose

The two most important recommendations in this report are;
1) for existing structures to implement defensible space techniques and be fire hardened to the greatest extent practical.
2) for ignition resistant construction and defensible landscaping to be incorporated into future development.

Structure hardening and ignition resistant plantings will be discussed later in this appendix, but first, we'll cover the basic practices involved in fuels management in the Home Ignition Zone. The defensible space concepts presented below can be applied to closely built groups of homes as well as individual homes built on larger lots with greater spacing. The authors and stakeholders of this report recognize the difficulty involved in coordinating large groups of homeowners and organizations such as HOAs; however, structure hardening and the creation of defensible spaces will produce the greatest benefits for the protection of life and the conservation of property from the effects of wildfire. For more information on broader community protection, please visit https://csfs.colostate.edu/wildfire-mitigation/ and https://fireadaptednetwork.org/ .

What is The Home Ignition Zone

There are primarily two factors that determine a home's ability to survive wildfire; the ignitibility of the structure and the quality of the defensible space surrounding it. These two factors are combined in the Home Ignition Zone (HIZ) (See **Figure 1**), which takes into account both the structure itself and the space immediately surrounding it when designing actions to mitigate the effects of wildfire.

One of the greatest challenges to limiting the potential damage from interface fires in the more densely populated areas of the West Metro Fire Rescue WUI is the lack of defensible space. In neighborhoods where homes are too close to create adequate individual defensible spaces, cross-boundary cooperation will be necessary to execute the most effective treatments. Throughout the study area, land adjacent to homes is of varied ownership, and any fuels modifications extending beyond lot boundaries will require collaboration and perhaps special permission to implement. Homeowners need to be aware they cannot cut and dump behind their property to create defensible space.

Under extreme conditions, wildland ignitions could quickly involve homes located on the edge of natural fuels and spread through neighborhoods by house-to-house transmission. This type of fire spread is similar to the 2012 Waldo Canyon fire near Colorado Springs that destroyed 486 homes and claimed two lives. It is not possible to develop individual defensible space where structures are spaced close together on small lots; however, it is possible to create linked defensible space by building defensible perimeters around clusters of dwellings and replacing flammable native and ornamental plantings near and between structures with ignition resistant plantings (See **Figure 2**).

The following general information regarding creating defensible space has been adapted from information available on the Colorado State Forest Service (CSFS) website. The specific distances quoted below are guidelines, and depending on circumstances of fuels, topography, and ownership, these distances may need to be modified. For more information, please see the CSFS publication *Protecting Your Home from Wildfire: Fire 2020-1,* which is expected to be publicly available in May 2021.

Defensible space is defined as an area around a structure that has been modified to reduce fire hazards. Natural and manufactured fuels are treated, cleared, consolidated, or substituted with ignition-resistant landscaping to slow the spread and intensity of fire. The development of defensible space involves three zones in which different techniques are deployed. These zones should be developed for every structure on the property, including detached garages, storage sheds, barns, etc., as well as the home. The specific design depends on many factors, including, but not limited to, the size and shape of buildings, construction materials, topography, and vegetative type.

Zone 1 extends from zero to five feet from the structure. Zone 1 distance is measured from the outside edge of the eves, decks, or other attached projections.

- In general, nothing should be planted in the first five feet from the structure, and ground cover should be non-flammable such as gravel, cement, or flagstones.
- Any cuttings, mulch, or woody debris should be removed.
- Pine needles and any other flammable debris should be removed from any decks or projections and raked to a distance of five feet away from these. Raking this material more than five feet has not been shown to reduce significantly the likelihood of ignition and is not recommended.
- Any branches that overhang the roof or are within 10 feet of a chimney should be removed.

Zone 2 extends from five to 30 feet from the structure and is managed to reduce the intensity of approaching fire. Fuels management in this Zone consists of the following:

- Remove any stressed, diseased, dead, or dying trees or shrubs.
- Create at least 10 feet of crown spacing between an individual or small groups of trees. Groups of two or three trees may be left in some areas, but a spacing of 30 feet is recommended between such groupings.
- Remove ladder fuels and prune branches from tree trunks up to a height of 6-10 feet or 1/3 of the tree height, whichever is less. Limbs should be cut no less than ¼ inch from the trunk to preserve tree health.
- Keep shrubs at least 10 feet away from tree branches and leave a minimum distance of 2 ½ times the mature height between groups of shrubs.
- Clumps of shrubs should be reduced in diameter to no more than twice the mature height.
- Mow grasses to a maximum height of four inches. This is especially important in the fall when grasses have dried out.

- Avoid heavy accumulations (known as jackpots) of fuels on the ground, including logs, slash, or mulch piles.

The distances given here are minimums and should be increased for slopes and dangerous terrain features. We strongly recommend a fire or forestry professional be consulted when planning defensible space in steep or complicated topography.

Zone 3 is designed to provide a gradual transition between Zone 2 and the natural vegetation condition of the surrounding lands. This zone extends from 30-100 feet from structures and is managed to promote vegetative health and limit fire behavior. Healthy forests usually contain various ages, heights, and species; however, reducing ladder fuels and maintaining or creating crown spacing should be primary concerns. Contacting the local CSFS office for guidance with Zone 3 management is highly recommended.

Remember creating defensible space is not a one-time job. Instead, defensible space must be maintained on an annual basis. A handy checklist of defensible space maintenance tasks is available from the CSFS website.

Figure 1 - The Home Ignition Zone

Figure 2: Linked defensible space example

Ignition-Resistant Landscaping

Ignition-resistant landscaping generally includes widely spaced trees, low-fuel volume shrubs, and herbaceous groundcover. Ignition-resistant, native re-vegetation should be considered at least as far as the 30-foot perimeter of Zone 2. In areas where it is practical and desirable, replanting with fire-wise species and implementing proper planting practices will provide the following benefits:

- Reduce the fire risk by limiting the ability of invasive and flammable species to return.
- Protect bare soils from erosion.
- Promote natural beauty and ecological stability without sacrificing adequate wildland fire protection.

Examples of fire-wise planting practices would be to space trees widely to interrupt the continuity of aerial fuels, plant low-fuel volume shrubs (usually no greater than 18 inches in height), and integrate decorative rocks and non-combustible natural features into the landscape architecture design. Deep watering trees through the summer and fall and during dry winters will keep trees alive and deter insects. Healthy, well-irrigated plants are less flammable, and irrigation systems can reduce the intensity and spread of surface fires.

Drought-resistant plants and irrigation systems should be utilized in newly planted areas. Existing native plants that are fire-adapted do not have to be replaced to reduce the fire risk; however, flammable species such as juniper should be avoided. Any retained natural vegetation needs to be maintained at a conservative fuel level and arrangement. Decorative rocks should be integrated into the design. Stone will help anchor and stabilize soil, create fuel breaks and

provide a natural look to the landscape. Emphasis should be placed on the use of Firewise species. A list of Firewise plants recommended by the CSFS can be found in their *Firewise Plant Materials* publication – http://extension.colostate.edu/topic-areas/natural-resources/Firewise-plant-materials-6-305/.

Careful planting of a Firewise landscape can provide open space and common areas with natural beauty and ecological stability without sacrificing adequate wildland fire protection.
To retain the health and vigor required to be fire-resistive, plants require maintenance. Maintenance of plant material is a critical factor in safeguarding these species' ignition-resistant qualities and continuing resistance to undesirable fire effects. On-going maintenance should include removing of dead material, weed control, cutting grasses to four inches or less, pruning trees and shrubs as necessary to prevent the buildup of ladder fuels, and removing surface fuel jackpots. Ladder fuels and fuel jackpots contribute to crown fire development and spotting during fires.

It is important to remember fire mitigation is not a one-time job. Defensible space should be maintained year-round, and reducing structural ignitibility is an ongoing process. The WMP should be reviewed and continuously updated to ensure the information regarding hazards and recommended solutions, and other important information presented there, stays current.

The Importance of Reducing Structural Ignitability and Individual Parcel Assessments

In their 2013 publication *How Risk Management Can Prevent Future Wildfire Disasters in the Wildland-Urban Interface,* David E. Calkin, Jack D. Cohen, Mark A. Finney, and Matthew P. Thompson come to the following conclusion:
"The demonstrated inability to suppress wildfires under extreme weather conditions and the fact that many homes are not destroyed when exposed to these wildfires indicates that reducing home ignition potential is key to effectively reducing home destruction. Because home ignitions are primarily determined by conditions on private property, the principal authority, and thus, primary responsibility for preventing WUI home destruction lies with homeowners rather than public land managers."[i]

As mentioned earlier, the HIZ is comprised of the structure itself and the area within the first 100 feet. Individual home hazard assessments can provide a road map for homeowners to reduce the ignition potential of the HIZ; however individual assessments rely heavily on the evaluation of conditions existing from the structure up to 100 feet out. As such, they are most effective when lot sizes are one acre or greater.

Homes in some of the residential hazard zones identified in this report, such as North Morrison, South Morrison, and Willow Springs to North Ranch, could receive the most benefit from parcel-level hazard assessments; however, in most of the WUI areas, homes are too close together and lots too small for individual parcel assessments to yield much actionable information. For that reason, we recommend individual parcel assessments focus on neighborhoods where the average lot size is one acre or larger. For the other communities of the study area, we recommend focusing on reducing HIZ ignition potential through linked defensible space and structure hardening tactics discussed below. In the neighborhoods where lots are large enough to benefit from parcel-level assessments, the data gathered should be integrated with data in the WMI (such

as structural ignitability data not captured by NoHARM) to establish a framework for future damage assessment responsibilities and recovery efforts.

Structural Hardening Recommendations

NEW DEVELOPMENT
The best time to reduce the ignitibility of a home is before it's built. Therefore, we recommend during the planning stage questions such as these be addressed:

- Are there multiple access points, and would access be safe for responders and evacuees during fire conditions?
- Can the adjacent fuels be modified to create adequate defensible space for homes considering the fuel type and topography?
- What are the potential fire behavior and ember cast from fires approaching the development during typical fire and extreme weather conditions?
- Will complex forms or flammable materials in the architectural design trap heat and embers?
- Does the design of homes and neighborhoods include adequate turnarounds and access for apparatus and sufficient water for fire suppression?
- Are streets and home addresses visibly marked with consistent, reflective signage?

EXISTING COMMUNITIES
Although some of the factors impacting the survivability of structures are best addressed before the home is built, there are still steps that should be taken to improve the chances of survival for existing homes.

The role of embers in structure loss cannot be overstated. Embers are generated by burning materials and lofted by wind and convective heat ahead of the main fire front. Structures are vulnerable to ember penetration in numerous ways. Some of the more common areas are outlined below.

Roof: Several homes and outbuildings in the study area have highly flammable wood shake roofs. The roof of a structure has a significant impact on its ignitability and the likelihood of house-to-house spread. Class A roofing materials such as asphalt shingle, metal, and tile roofs are all considered ignition resistant. There are also many homes in the study area using wood for architectural features. We recommend that future use of any wood shingle be prohibited and non-flammable materials should be strongly encouraged when existing elements need repair or replacement.

Decks: There are quite a few homes with wooden decks and projections. According to CSFS, wooden decks are so combustible that "when a wildfire approaches, the deck often ignites before the fire reaches the house."[ii] The shape of decks and outdoor stairs makes them excellent traps for heat and embers. Nothing flammable should ever be stored under decks or projections because of this.

We recommend that as wooden decks and projections found throughout the study area become in need of repair or replacement, non-flammable materials, such as plastic composites or aluminum decking should be strongly encouraged. The quality and number of choices for wood substitute building materials have grown exponentially in the last decade, and homeowners are no longer limited to materials with an inferior look and finish. In addition to reducing fire hazards, these materials usually require much less maintenance than wood. In areas where fire behavior predictions call for low to moderate intensities, it is helpful to isolate existing wooden decks from the energy of fires by building a non-combustible patio and wall below the deck to limit the heat trap effect. The best design is to enclose the deck completely to create a solid form.

WINDOWS quickly fail when exposed to the radiant heat of a wildfire. Once windows have failed, they provide a direct path for embers and heat to enter the home and ignite the inside. Although some of the newer homes in the study area have more heat resistive windows, such as low E Thermopane (double glazed) and tempered glass patio doors, most older homes are likely to have conventional single-pane window glass. This is especially true of homes that were built originally to be seasonal or vacation residences.

We recommend replacing single-pane windows with modern double-pane windows that will improve the resistance to breakage from heat exposure by up to double the exposure time.[iii] Homes near heavy fuels should consider installing heavy, non-flammable window coverings that will afford the home some additional protection from embers in the event windows break. Homes in these areas should also consider replacing large windows (2 feet or more wide or tall) with smaller panes that are more likely to stay in place even if fractured by heat.

VENTS are another location where embers can enter the structure. Vents, especially vents on the downhill side of the home, should have flammable vegetation removed as per Zone 1 defensible space standards and be protected by non-flammable landscaping features such as stone or brick that will block the heat path of the fire. Vents in eves and soffits should be covered with a non-combustible mesh with openings 1/8” or smaller to slow the ingress of embers. Any open eves should be enclosed to prevent them from becoming a trap for heat and embers. When enclosing an open eve, a flat soffit is preferred over a sloping soffit to limit the heat trap effect.

PROPANE TANKS Any above-ground propane tank should be kept at least 30 feet from structures, and all flammable vegetation should be removed from within 10 feet of tanks, lines, and meters.

Historic fire events have proven that poor construction techniques and materials are linked directly to structure loss, reinforcing the message of the research quoted earlier in this appendix. The Insurance Institute for Business and Home Safety (IBHS) wildfire research center has developed a video demonstrating how various home construction materials burn during an ember storm (https://www.youtube.com/watch?v=IvbNOPSYyss).

For more detailed information regarding structure hardening and construction method and material vulnerabilities, please see the CSFS publication *Firewise Construction: Site Design & Building Materials,* which can be downloaded from the CSFS website at

https://csfs.colostate.edu/wildfire-mitigation/construction-design-materials/ and the following links:

- https://fireadapted.org/wp-content/uploads/2018/06/waldo-canyon-report.pdf (Lessons learned from the Waldo Canyon Fire)
- https://www.fema.gov/media-library-data/20130726-1652-20490-4085/fema_p_737.pdf (FEMA *Home Builder's Guide to Construction in Wildfire Zones*)
- https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1141 National Fire Protection Association (NFPA) 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas*.
- https://www.youtube.com/watch?v=vL_syp1ZScM *Your Home Can Survive a Wildfire* NFPA video presentation.

REFERENCES/CITATIONS

[i] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3896199/

[ii] https://static.colostate.edu/client-files/csfs/pdfs/FIRE2012_1_DspaceQuickGuide.pdf, Page 4.

[iii] https://static.colostate.edu/client-files/csfs/pdfs/firewise-construction2012.pdf, Page 30.

Appendix B: Evacuation Discussion & Recommendations

Purpose

The purpose of this appendix is to discuss evacuation and resource access issues specific to fire in the Wildland Urban Interface and Wildland Intermix areas of the study area. Recommendations will be presented in conjunction with results of the Time Until Fire Arrival and ember cast severity modeling of alternate escape routes.

The main corridors through the study area are I-70, US-6/US-40, US-285, C-470, and CR-8. Although there are several subdivisions with homes located on dead ends and cul-de-sacs, the communities east of C-470/I-70 have reasonable access to at least one of these primary corridors. Communities where evacuation is more complex include South Table Mountain, Willow Springs to North Ranch, Ken Caryl Valley, and Roxborough/Ravenna. Time Until Fire Arrival (TUFA) has been modeled for six alternate routes chosen by West Metro Fire Rescue (WMFR) through three of these communities.

General Recommendations

Pre-planning is critical to successful evacuation of any threatened population. In all the communities mentioned above, an evacuation pre-plan should be developed and reviewed annually for continued accuracy. This is especially important in areas where development is ongoing. As primary and alternative evacuation routes are developed, we recommend adding signs, similar to the example in **Figure 1**, at every junction marking the route as a wildfire evacuation route. All the primary and alternative roads should be inspected periodically at junctions to be sure they have reflective signage with at least 4-inch tall characters.

Figure 1, Evacuation Route Signage Example

While street signs in the study are generally good and most road junctions marked, there are some areas where street signs are not reflective, and many homes throughout the study area do not have an address marker visible from the street. Where address markers do exist, they vary in size, reflectivity, and position. Although mapping applications such as Google Map and Waze have made it easier for responders to locate specific structures, reflective addressing visible from the street is still desirable. Most applications relying on GPS technology have difficulty pinpointing addresses from time to time. While some residents may consider reflective address signage unattractive, it is a desirable aid for quick and effective response. The value to responders, especially at night and under difficult conditions, is not to be underestimated. This is especially true during large wildland fires where poor addressing will create an additional challenge for outside responders who do not possess local knowledge and training regarding access.

Although consistent, reflective street and address markers seem less relevant with today's technology, it's important to remember that technology does fail. A program of improving road and address markers throughout the study area is recommended. We recommend WMFR, all existing or planned HOAs, appropriate local governmental entities, developers, and property owners work together to create and implement a consistent system of reflective address markers. If the residence is not visible from the street, an address marker should be located on the street at the entrance to the driveway. An additional address marker showing all residences located on communal driveways should be placed where the private drive joins a public road.

Access road vegetation management is recommended for all primary and alternate access/evacuation routes. Fuels should be monitored along all these routes to be sure flammable vegetation does not compromise their use during wildfire events. Limbing and thinning should be conducted in any section where fuels are found near the road. Hazardous trees and shrubs should be removed within 10 feet of the roadway and any grasses mowed to a height of no greater than four inches. Trees should be trimmed to at least a height of eight feet for trees 25 feet or taller and 1/3 the tree height for smaller trees within 30 feet of the roadway to prevent surface fires from laddering into the canopy near the road.

The WMI should be utilized to be sure information regarding evacuation routes is updated frequently during the fire season and remains current.

Shelter-in-Place

Evacuation is the priority for homes throughout the study area threatened by wildfire, however, some residential areas could face evacuation challenges created by steep, narrow roads, heavy fuels, and other operational difficulties.

Traditionally in the United States, the preferred method of protecting the public from an advancing wildfire is evacuation and involves relocation of the threatened population to a safer area. When this tactic is impractical or too hazardous, another possibility is to instruct people to remain inside specially prepared buildings until the danger passes.

Shelter–in-place should only be considered when the structure is determined to be "stand-alone" in structural triage terms. To be "stand-alone", a combination of ignition-resistant construction and fuels reduction, is necessary to provide reasonable protection to people inside from a wildfire and create an environment safe for firefighters to defend the structure. The building must have ventilation that can be easily shut down and isolated from the outside air to retard smoke infiltration. To be "stand-alone", buildings must be of ignition-resistant construction and have adequate defensible space.

Ignition resistant construction is necessary for shelter-in-place tactics. Structures with wooden roofs, flammable decks or projections, or untreated wooden sidings are particularly hazardous and should not be considered for shelter-in-place. Structures should have ignition-resistant roofs and ignition-resistant siding, such as stucco or concrete, especially close to the ground. Eaves should be enclosed, and any holes in the foundation, siding or eves should be covered to prevent embers from entering. Buildings with large areas of non-burnable surfaces adjacent to them, such as paved parking lots and bare earth, are desirable.

Defensible space fully conforming to the most current standards is also a requirement. For a detailed discussion of defensible space, see *Appendix A, Home Ignition Zone Recommendations*.

Although evacuation is preferred under most conditions, there may be some areas where high numbers of people attempting to evacuate on residential streets may create a more dangerous situation than pre-planning shelter-in-place safety zones for residents and visitors. Schools, public buildings, and large event centers such as Red Rocks Amphitheater may be suitable for this purpose. We recommend WMFR, local government, and law enforcement work together to identify neighborhoods where pre-planning shelter-in-place locations could be a desirable alternative to evacuation.

Time Until Fire Arrival (TUFA)

Anchor Point's Time Until Fire Arrival (TUFA) modeling calculates how long it will take fire to reach a specific value at risk (in the case of this study, an evacuation route). Traditional fire behavior predictive modeling is designed to characterize fire moving away from a pre-determined point of ignition, while TUFA modeling starts away from the evacuation route and calculates how long the fire will take to reach that route from any potential ignition point on the landscape. This produces a map of the time responders have to move a threatened population away from danger. This analysis can be used to identify portions of evacuation routes susceptible to rapid-fire impingement and aid in evacuation planning. Once problem sections are identified, fuel reductions and other mitigation can be prescribed. This analysis, in conjunction with traditional fire behavior modeling, can pinpoint areas where heat and smoke are most likely to impact escape routes. Adjustments and alternatives can be investigated to avoid critically impacted areas. Such information regarding areas where time for response and operations is limited allows for more precise pre-planning and incident response.

Using TUFA, Anchor Point has modeled six alternative evacuation routes selected by WMFR in communities where evacuation will be difficult. TUFA is a surface fire calculation that does not include modeling for fire spread by ember cast. TUFA is also designed to be conservative,

assuming a worst-case scenario in terms of the speed a fire moves. Actual arrival times may be slower than those represented on the following maps. The TUFA analysis also assumes that fuel is directly adjacent to an evacuation route in order to accurately model an arrival time. In situations where there is a gap (such as a golf fairway or parking lot) between an evacuation route and the fuel bed, arrival times reflected on the other side of the gap will likely be shown as longer than they would be if the fuel bed were directly adjacent to the evacuation route.

Although the effects of ember cast on rate-of-spread are highly dependent on weather and fuel conditions, the graphic following each of the TUFA graphics shows predictions of the expected extent and severity of ember cast based on standard conditions. The red zone indicates areas where the model predicts a high probability of significant ember cast, and the yellow zone is where some ember cast is expected but for it to be less of a factor in fire spread. The risk situation of each evacuation route is best analyzed examining both TUFA maps and the ember cast maps shown below.

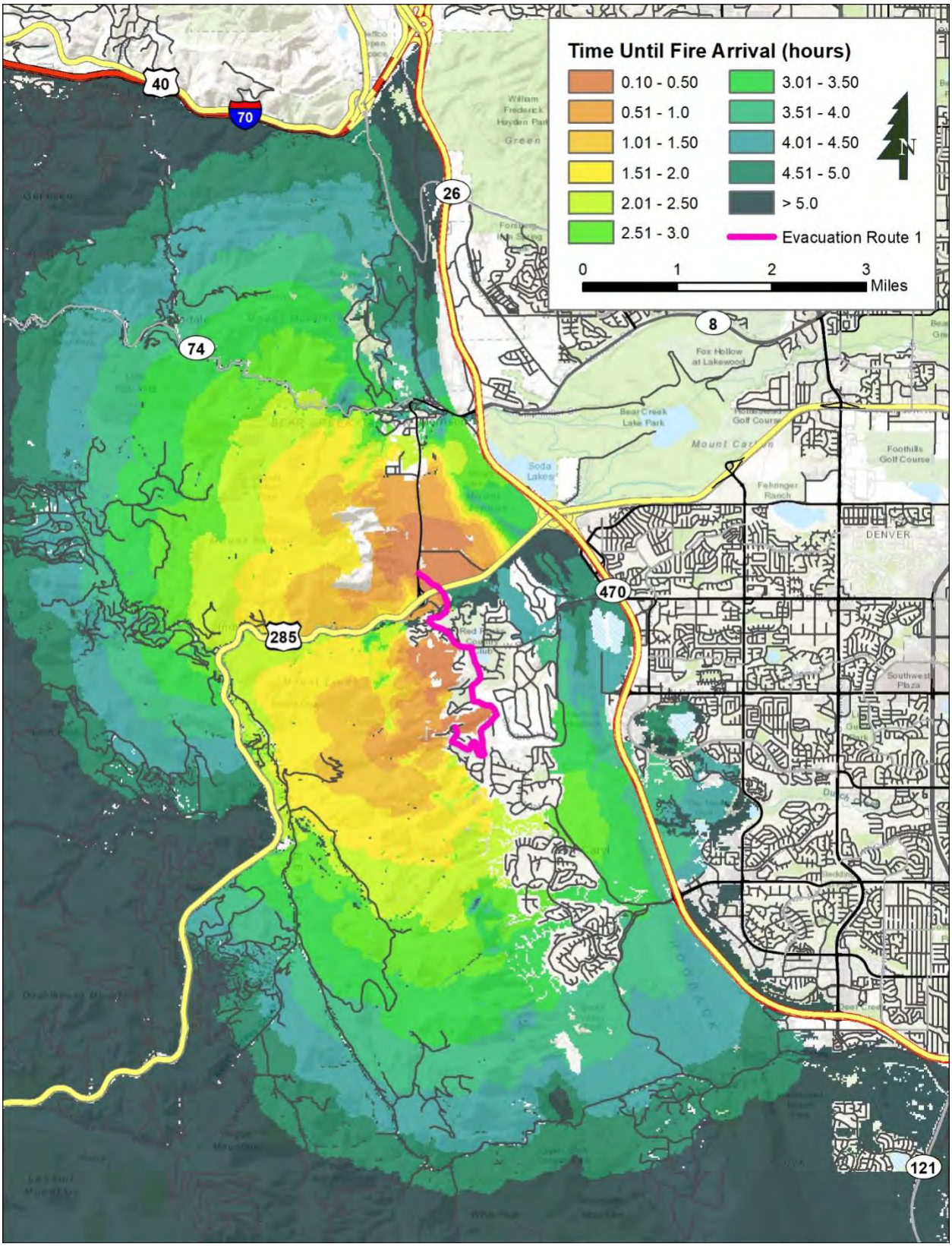


Figure 2, Evacuation Route 1, TUFA

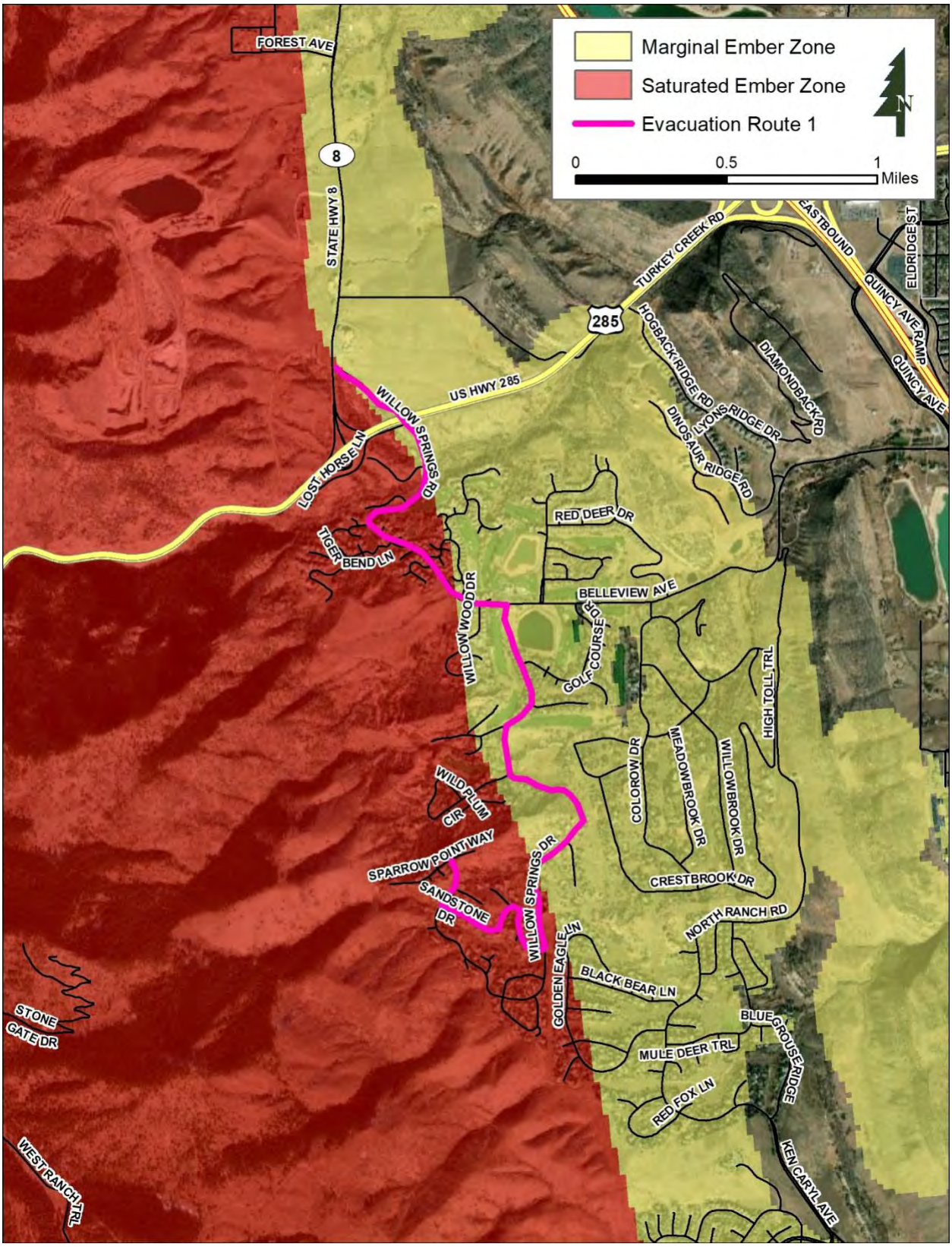


Figure 3, Evacuation Route 1, Ember Zones

EVACUATION ROUTE 1

Evacuation Route 1 runs along the west side of the Willow Springs community and offers an alternative to evacuating to C-470 by neighborhood streets or US-285. This route avoids the saturated ember zone except for two sections with no alternative and connects the south end of Willow Springs Drive to US-285 and C-8. TUFA shows fires occurring for a substantial distance west of this neighborhood in the Willow Springs Open Space will reach most of this evacuation route in less than one hour. Extensive preplanning and rapid response will be required to make this route a reasonable alternative for evacuation from the west side of Willow Springs, however, if properly utilized, this route could reduce the possibility of bottlenecking on Belleview Avenue and Ken Caryl Avenue by distributing some of that traffic volume to C-8 and US-285.

The 2015 Willow Springs Open Space Forest Stewardship Plan recommended oak brush management along the Willow Springs Open Space (WSOS) eastern border closest to private residences. Mosaic cutting in five management units on 51.2 acres was recommended to reduce fuels continuity to homes.[i] Implementation and maintenance of this recommendation will help interrupt fuels continuity in some areas where TUFA has predicted ignitions could reach Evacuation Route 1 within an hour accompanied by severe ember cast. We recommend any work not completed in these oak management zones be implemented and these zones evaluated annually for maintenance cutting.

We also recommend portions of this evacuation route that fall within the saturated ember zone be evaluated for roadside thinning as described in the *General Recommendations* section of this Appendix.

Although there is a road from Willow Springs to North Ranch, access is blocked by a locked gate. This access would probably be most useful for evacuation from Willow Springs into North Ranch, and creating a one-way emergency egress should be considered. The gate, however, could create confusion for visitors, and some residents, should the need arise to use this route for evacuation during a fire, even if the gate is unlocked by firefighters. We recommend adding a sign marking the route as a wildfire evacuation route, as shown in **Figure 1** in the *General Recommendations* section.

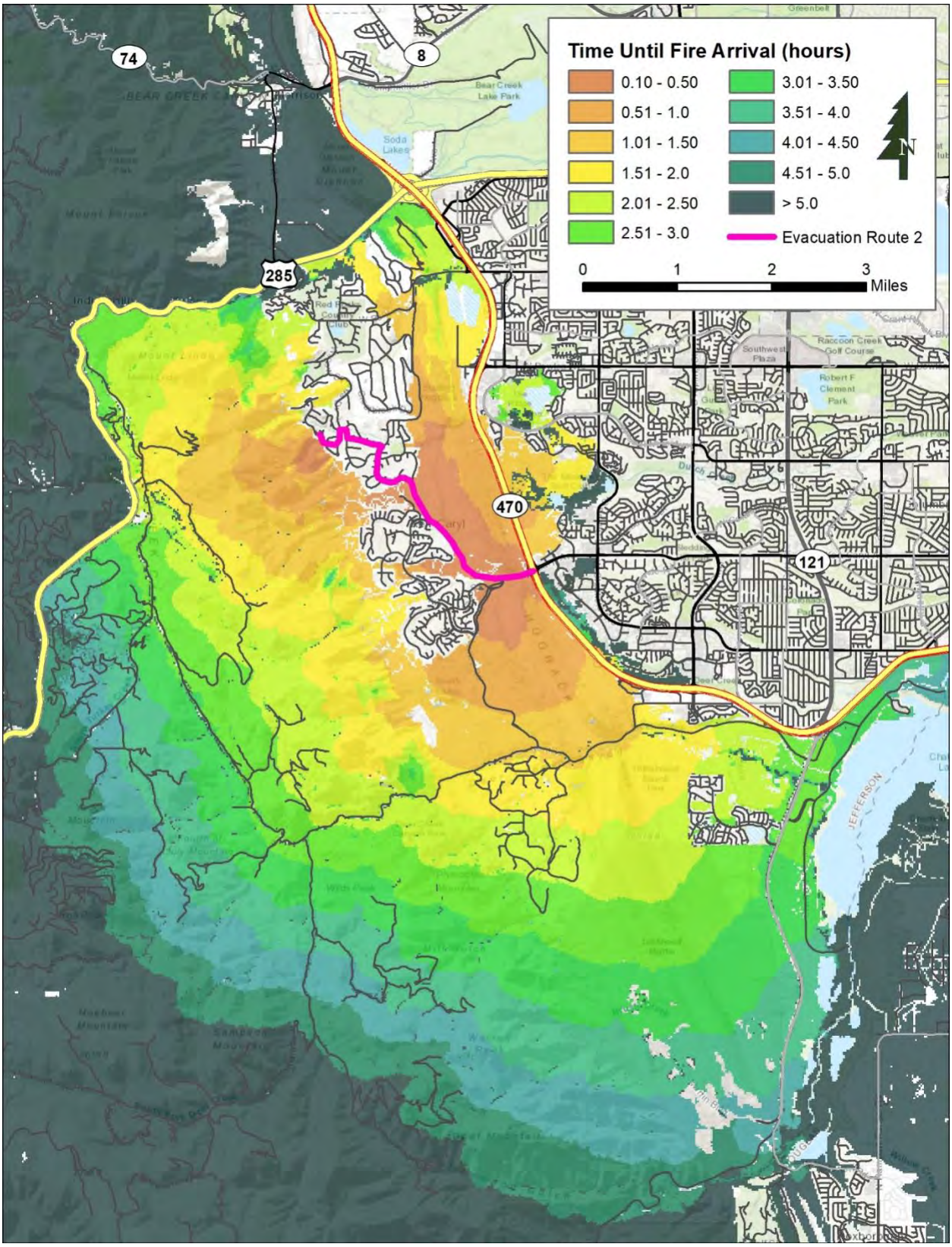


Figure 4, Evacuation Route 2, TUFA

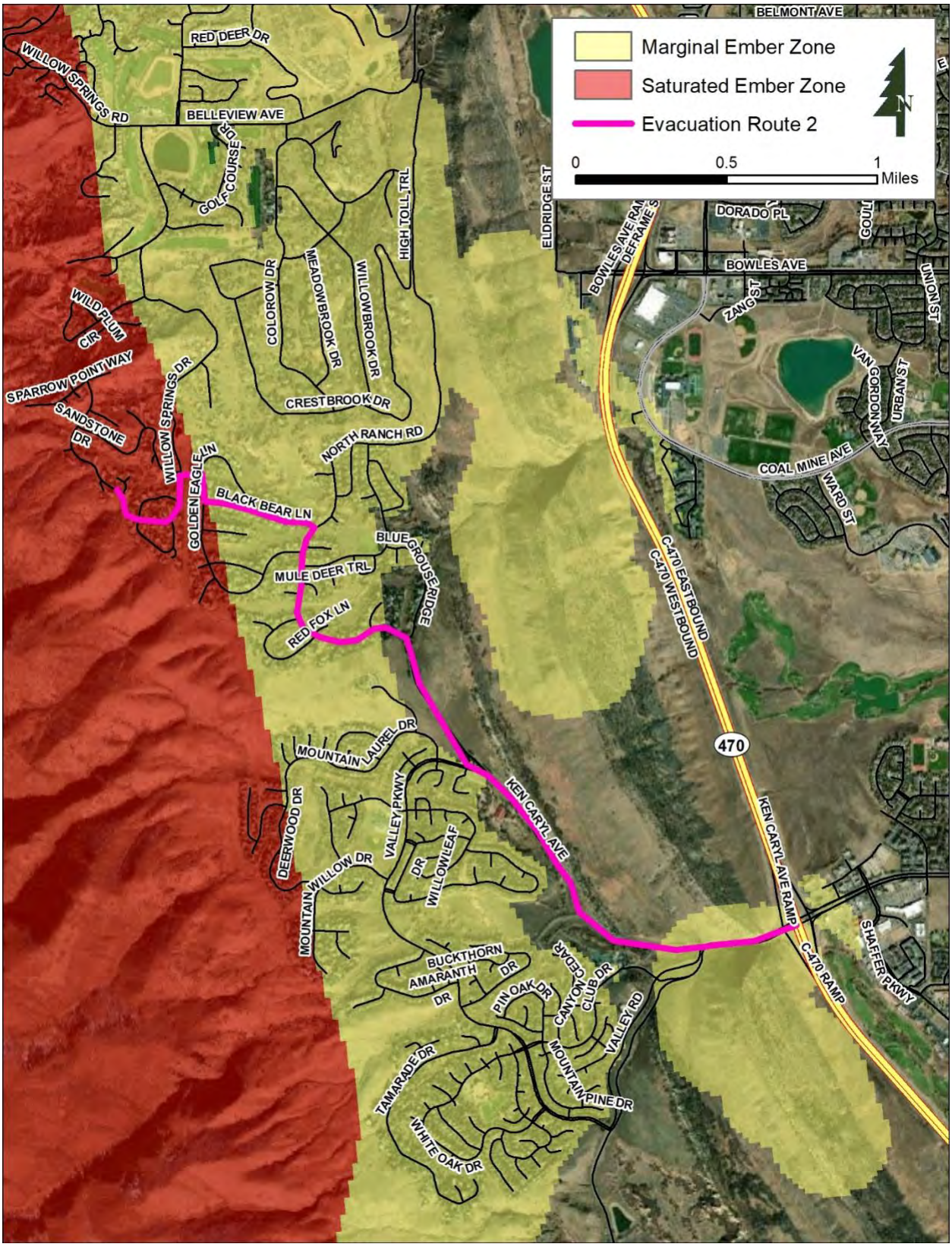


Figure 5, Evacuation Route 2, Ember Zones

EVACUATION ROUTE 2

Evacuation Route 2 runs from the west side of North Ranch along Ken Caryl Avenue connecting with C-470. Although it is possible to escape Ken Caryl Valley via North Ranch Road to Belleview Avenue, there is a gate that blocks access. This route is probably better utilized as an escape from Willow Springs to Ken Caryl Avenue. Although it is also possible to escape Ken Caryl Valley to the south via Valley Road, Evacuation Route 2 is the primary escape route for North Ranch and Ken Caryl Valley.

Considering the critical importance of this route to a considerable number of residences, we recommend the entire route be treated for fuels reduction as described in the *General Recommendations* section and inspected annually for any needed maintenance cutting. The highest priority should be the portion of Black Bear Lane that runs through the saturated ember zone.

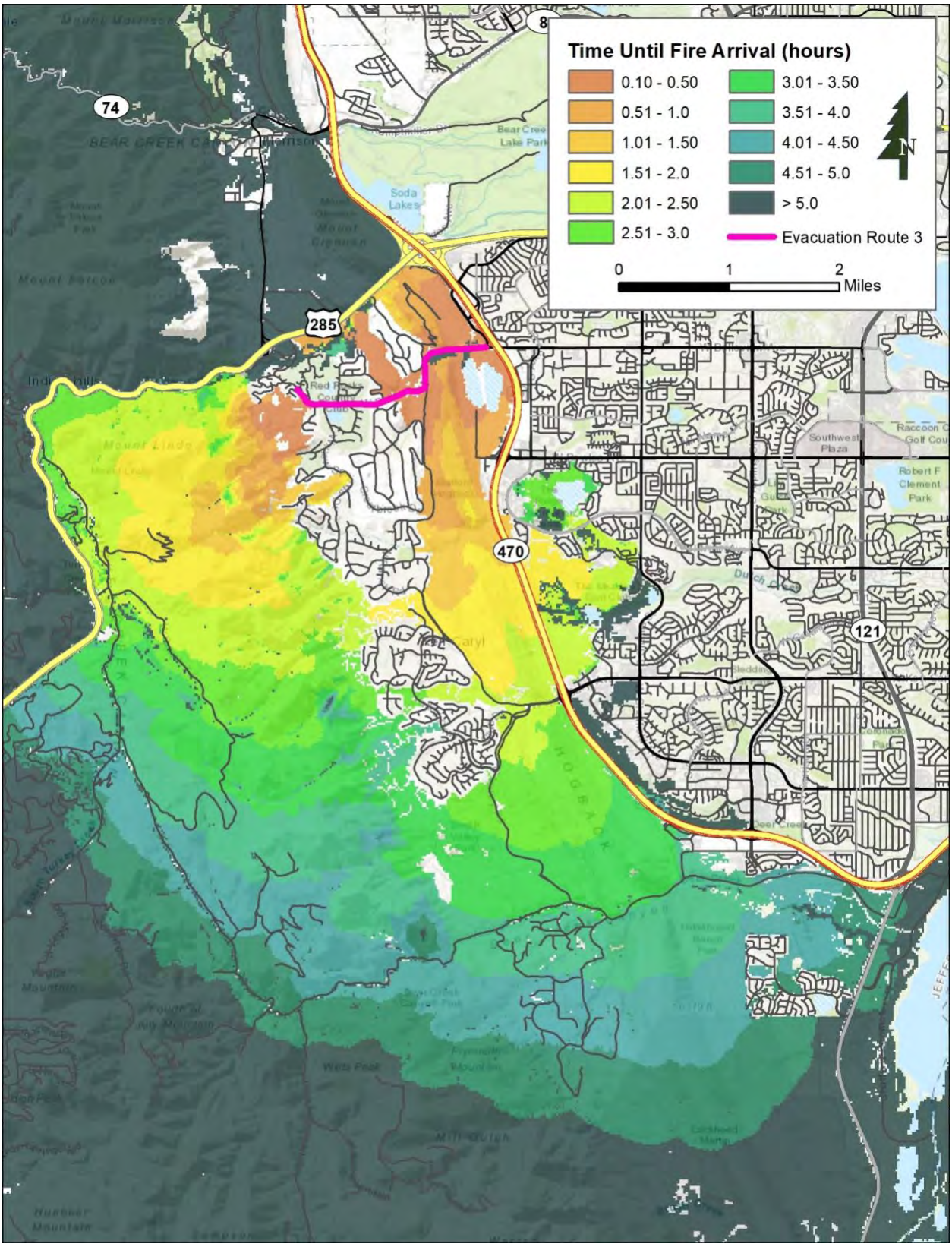


Figure 6, Evacuation Route 3, TUFA

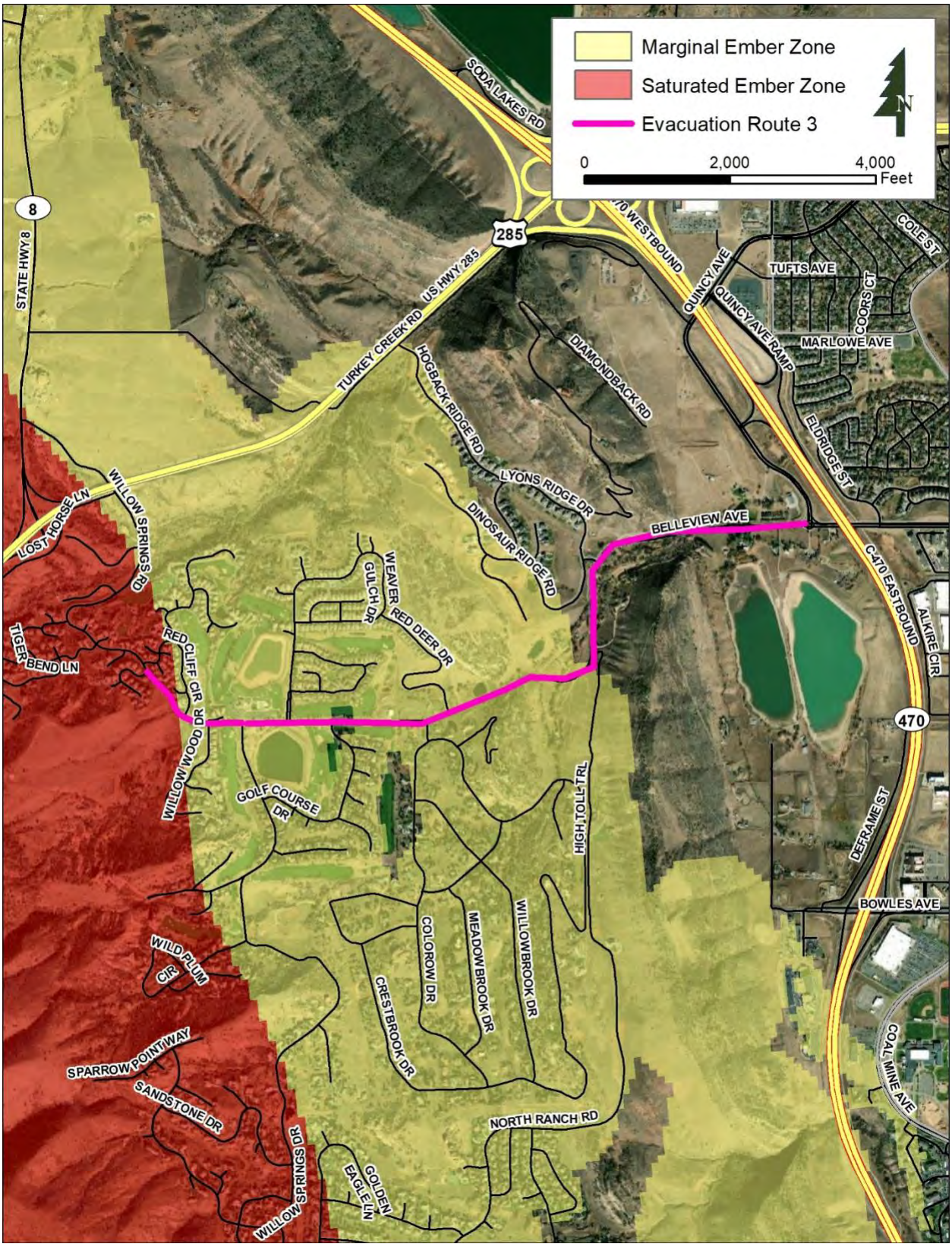


Figure 7, Evacuation Route 3, Ember Zones

EVACUATION ROUTE 3

Evacuation Route 3 runs east/west from Willow Springs Road to E. Belleview Avenue and connects with C-470. This route offers the most direct way out for most homes in the Montane, Willow Springs and Willowbrook neighborhoods. Although the golf course provides a break in the continuity of the native fuels along this route, there are still some sections that run through heavy loads of oak brush and native grasses.

The entire distance of this route, from the end of Willow Springs Road to C-470, should be evaluated for fuels reduction. Any areas where vegetation encroaches on the road should be treated as described in the *General Recommendations* section and inspected annually for any needed maintenance cutting. The highest priority areas should be the roads feeding into W. Belleview from the neighborhoods west and south of the golf course and the portion of W. Belleview between Colorow Road and Quincy Avenue surrounded by native vegetation.

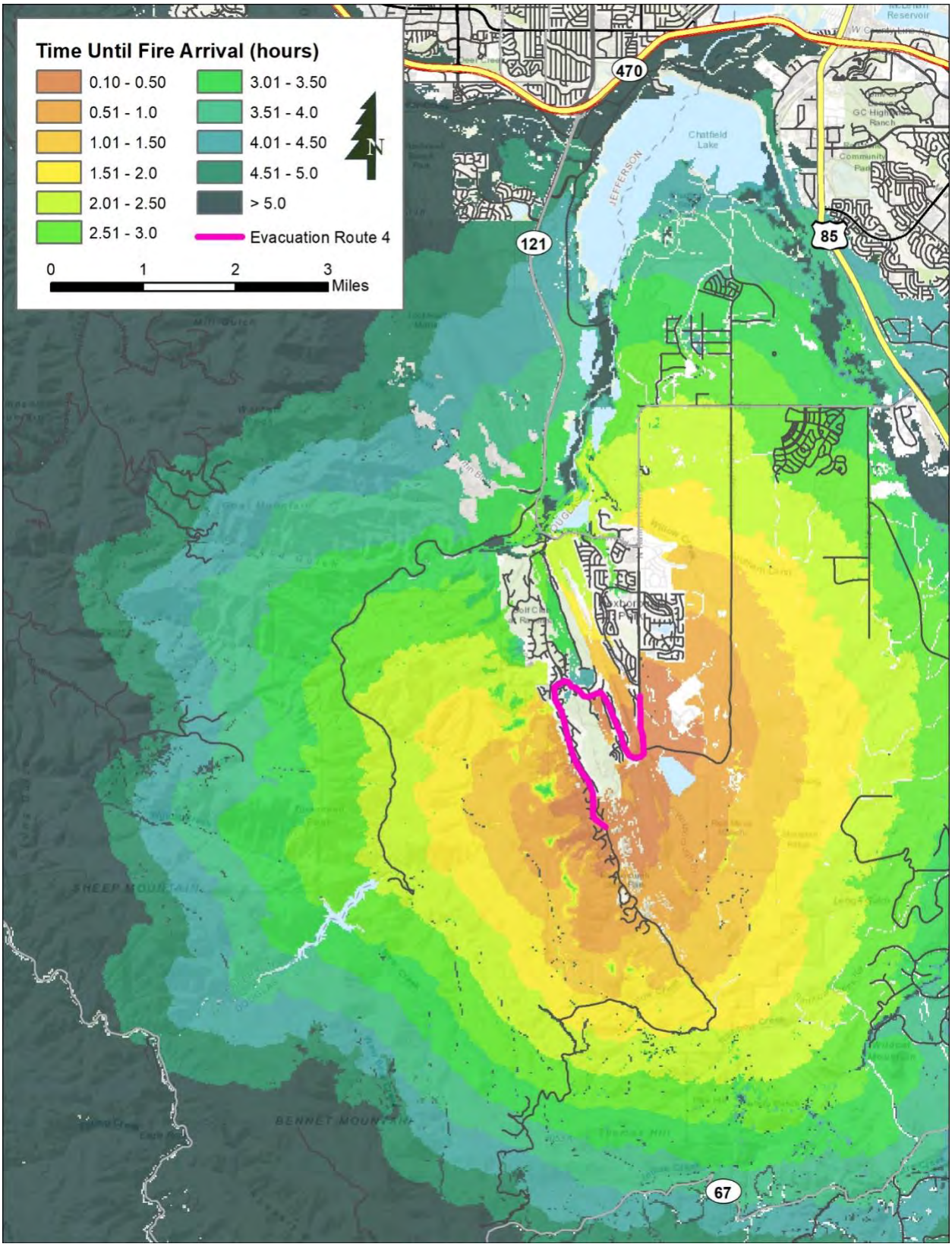


Figure 8, Evacuation Route 4, TUFA

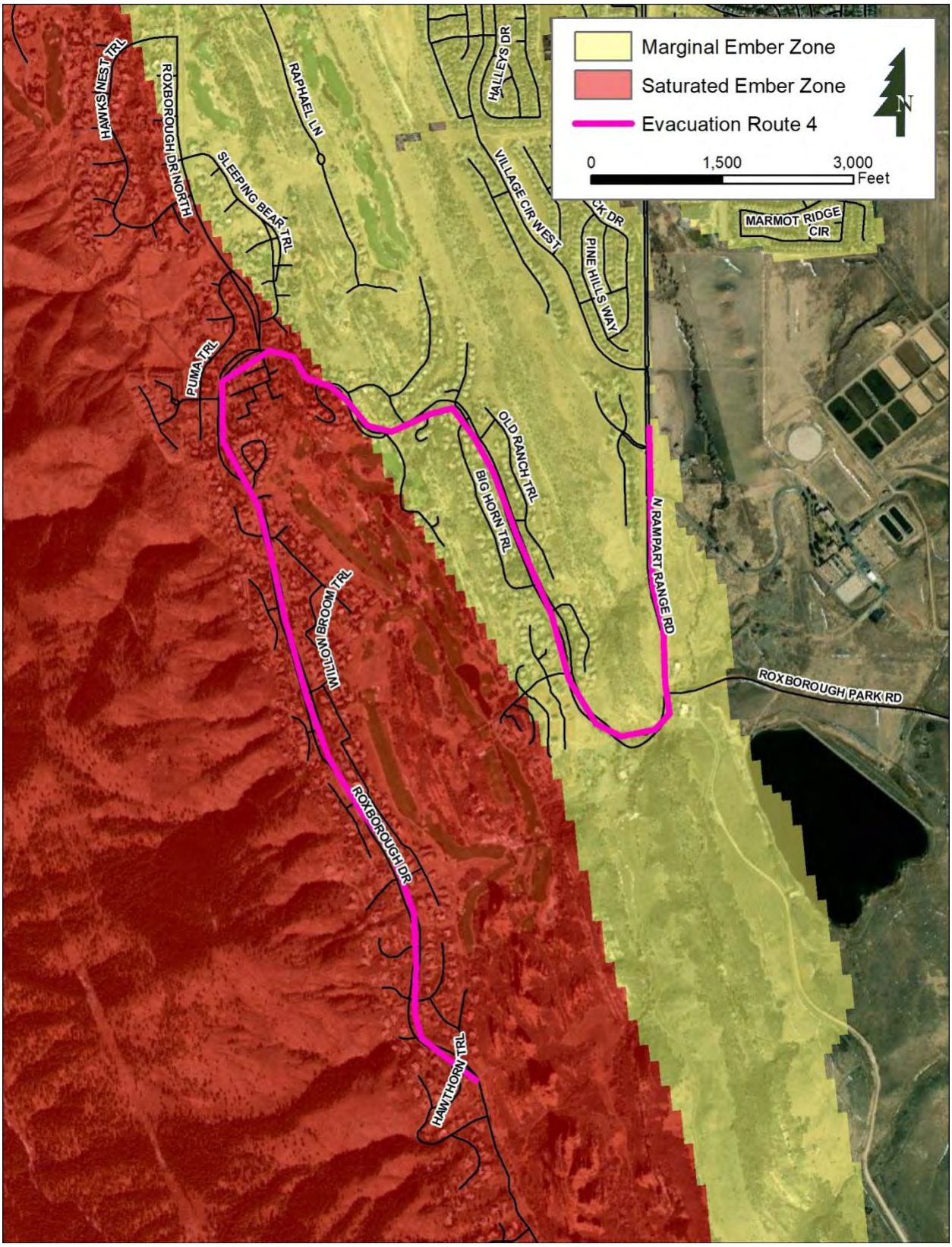


Figure 9, Evacuation Route 4, Ember Zones

EVACUATION ROUTE 4

Evacuation Route 4 runs from the south end of Roxborough Park along Roxborough Drive and exits into Roxborough Village on N. Rampart Range Road.

Although Dante Drive is the main entrance into the Roxborough Park/Ravenna community (see Evacuation Route 5), this is a gated entrance and likely to bottleneck quickly during an emergency evacuation making Evacuation Route 4 a critical alternative for most of Roxborough Park. This route, along with Evacuation Routes 5 and 6, is also described in the 2020 Roxborough Park CWPP Update.[ii]

The *Douglas County All-Hazards Evacuation, Alert and Warnings Annex of the Douglas County Comprehensive Emergency Management Plan* includes an alternative for the southern part of Roxborough Park that crosses the Arrowhead Golf Course cutting the northern loop off Evacuation Route 4.[iii] This route is also shown as the "Golf Course Evacuation Route" (their Route 2) in the *Roxborough Park Wildfire Evacuation Guide* (Figure 10*)*. If this route is to be used in conjunction with Evacuation Route 4, pre-planning and coordinated evacuation incident management will be required to prevent traffic jams on the narrow trail through the golf course and at the junction where the alternative route rejoins Roxborough Drive. The same Douglas County document describes a short but potentially useful route crossing the Golf Club at Ravenna (Figure 11) as well as Evacuation Route 5, shown below.[iv]

The *Roxborough Park Wildfire Evacuation Guide* also shows two additional routes from the Ravenna neighborhood; the "Northwest" route (their Route 3), Roxborough Drive north via Ravenna, and the "Northeast" route (their Route 4), Fox Paw Trail via Ravenna. Both of these routes rely on exiting through the gated entrance on Dante Drive at Waterton Road, a bottleneck that will likely create traffic jams during an emergency evacuation unless precisely managed.

Most of Roxborough Drive is in the saturated ember zone, and several sections are surrounded by oak brush. Moderate to heavy loads of oak brush encroach the road in multiple areas, and stringers and patches exist in some medians. The entire distance from the southern end where Roxborough Drive becomes a dirt road to where N. Rampart Range Road becomes a four-lane divided highway should be evaluated for fuels reduction. All areas where vegetation encroaches on the road should be treated as described in the *General Recommendations* section and inspected annually for any needed maintenance cutting. The highest priority area should be Roxborough Drive south and west of the Arrowhead Golf Course.

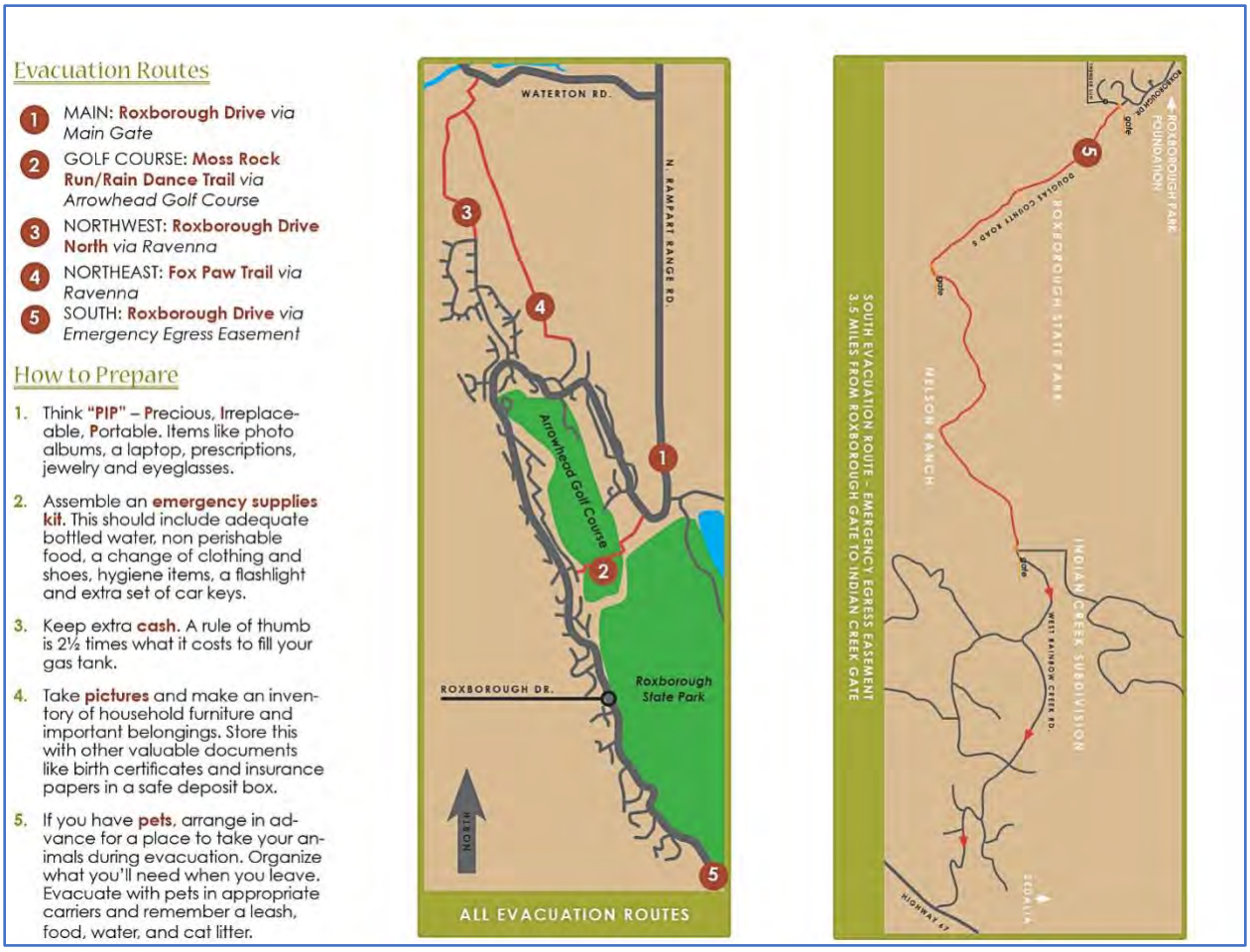


Figure 10, Roxborough Park Wildfire Evacuation Guide, Page 1

27. ROXBOROUGH

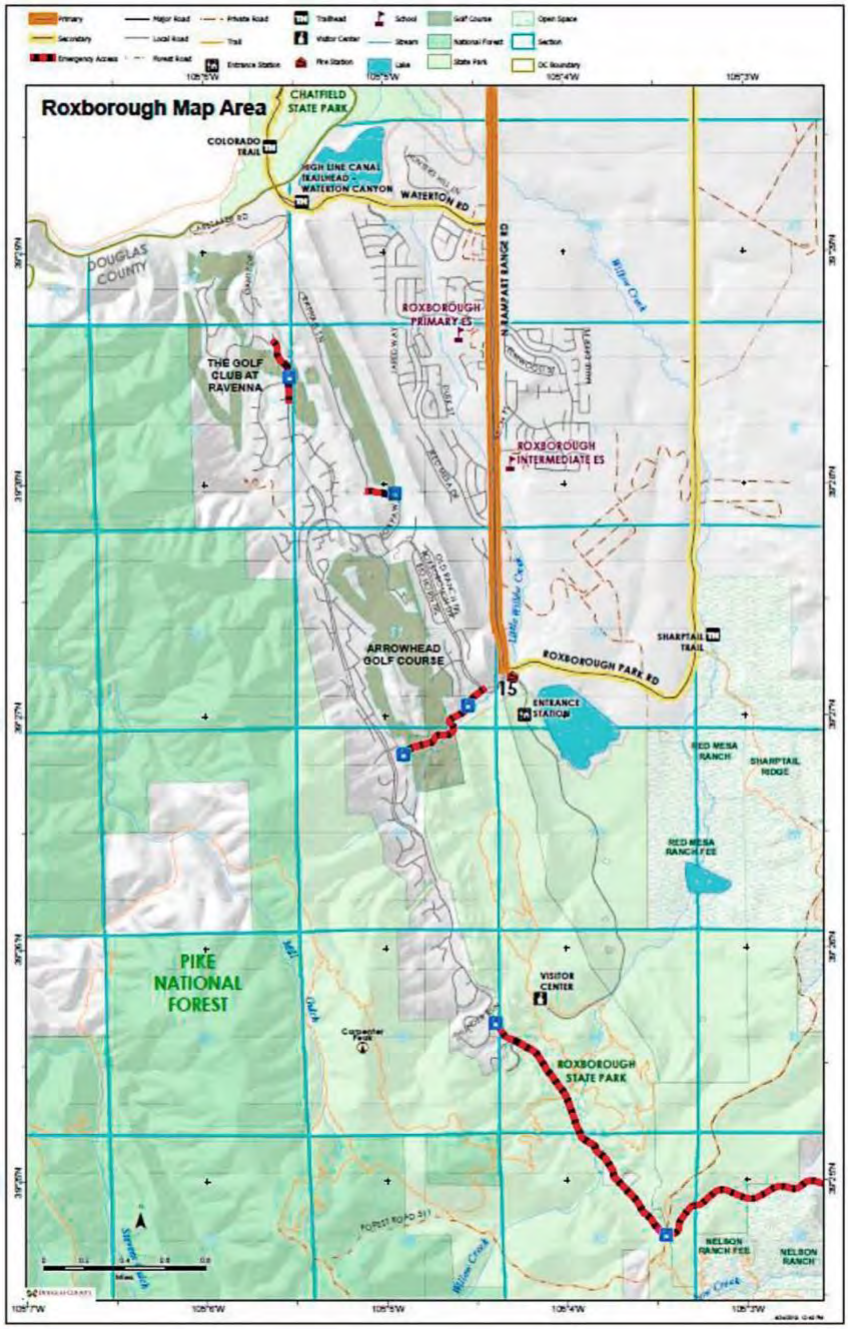


Figure 11, Douglas County Evacuation Routes for Roxborough

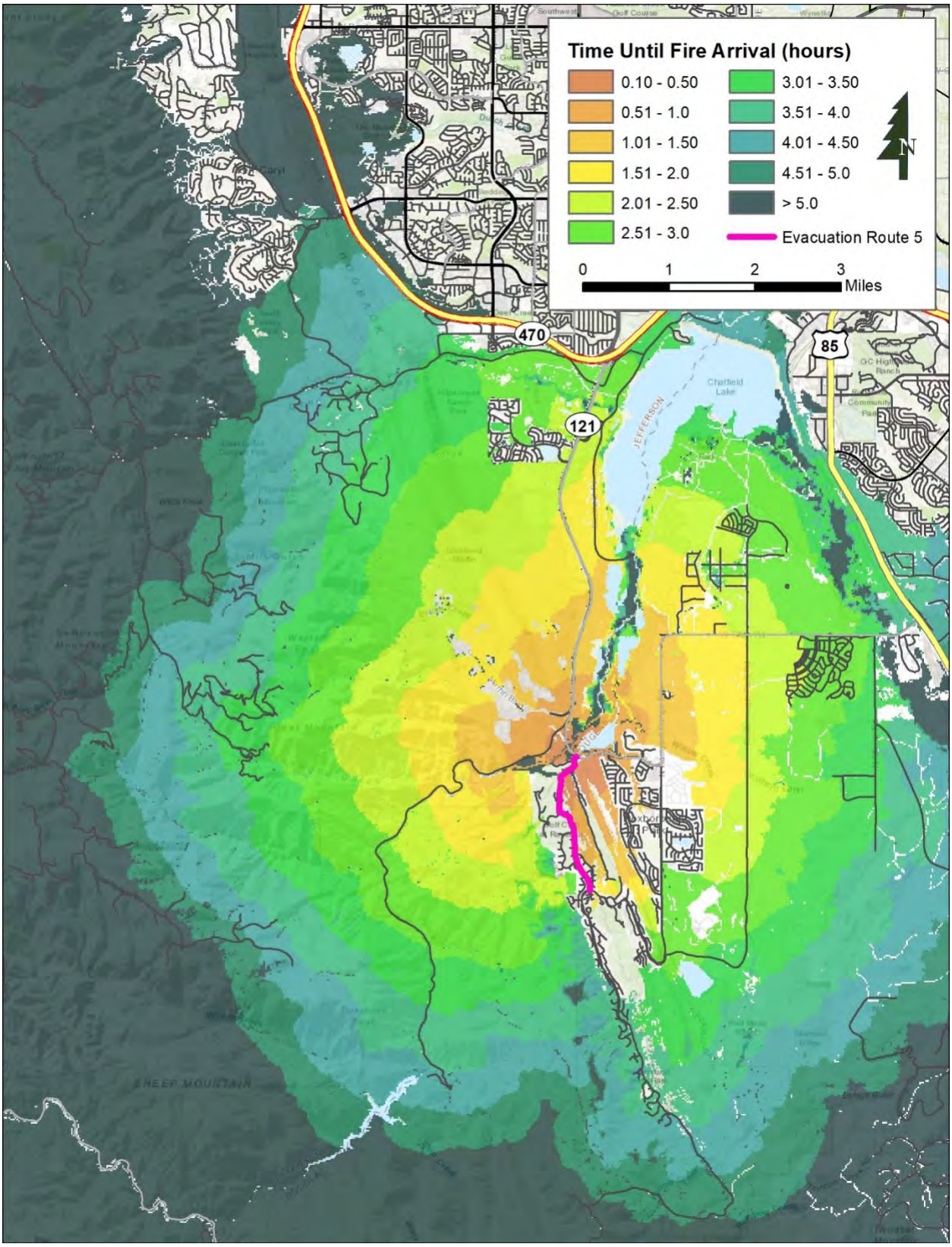


Figure 12, Evacuation Route 5, TUFA

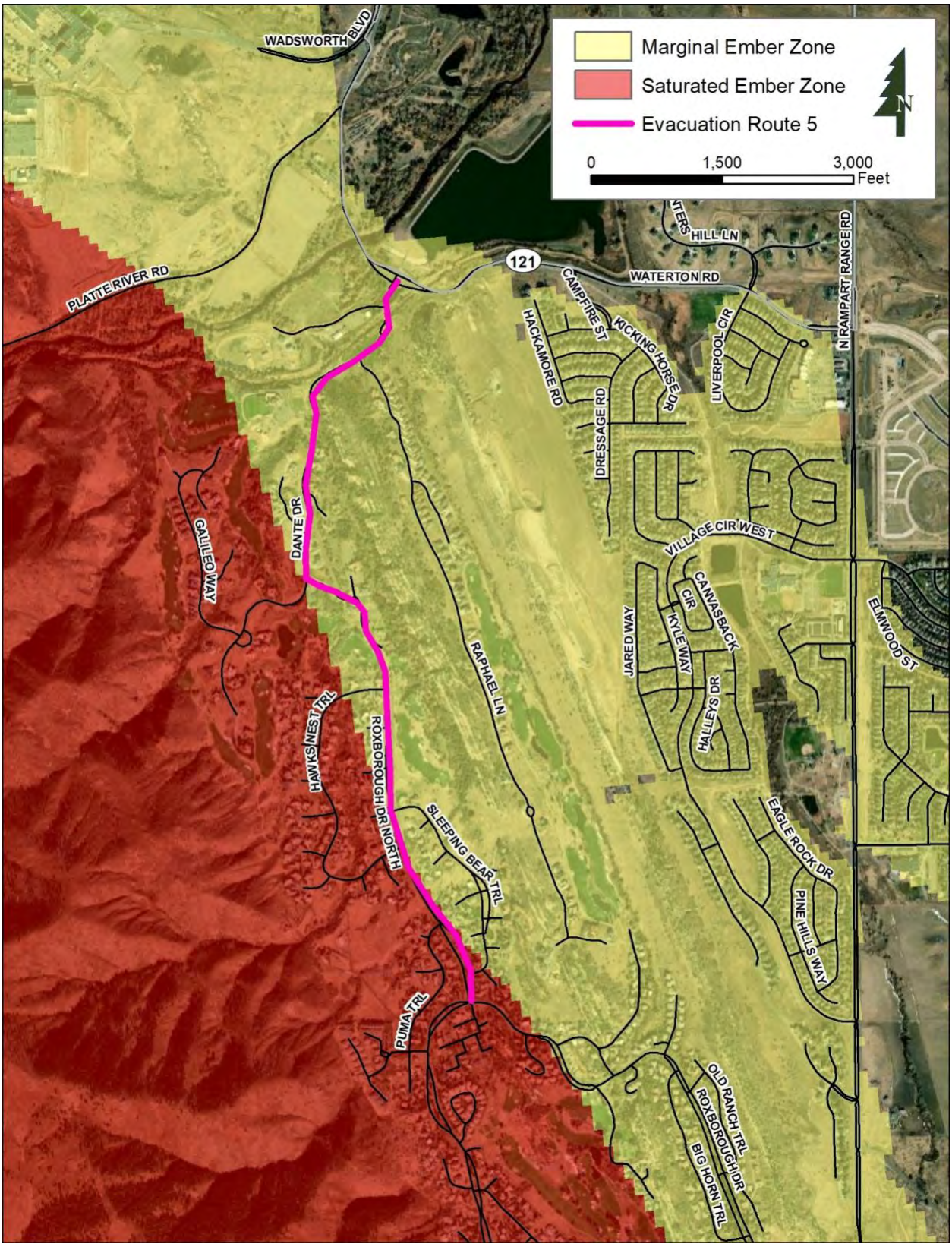


Figure 13, Evacuation Route 5, Ember Zones

EVACUATION ROUTE 5

Evacuation Route 5 runs from the north end of Roxborough Park through Ravenna along N. Roxborough Drive and Dante Drive to Waterton Road. As previously mentioned on page B-16, the only exit from this route is a gated entrance likely to bottleneck quickly during an emergency evacuation unless precisely managed. Pre-planning a staged order of evacuation for the neighborhoods serviced by this route may help relieve congestion; however, this solution may not be practical. TUFA shows ignitions occurring in the oak brush and grass fuels on both the east and west sides of the entrance would impinge Dante Drive in less than one hour.

Although only the southernmost part of this route along Roxborough Drive is in the saturated ember zone, continuous stringers of oak brush occur along the entire east side of this route between the roads and the hogback. Large patches of oak brush also exist west of Dante Drive on the north side. Where these large concentrations of oak brush exist, we recommend thinning to break fuel continuity, increase open areas and improve the health of the remaining oak. The remaining clusters should be no larger than 40 feet in any direction, with a spacing between groupings of at least 2 ½ times the height of the tallest remaining oak. The highest priority area should be west of Dante Drive to the golf course greens and east between Dante Drive and Raphael Lane from the intersection with N. Roxborough Drive to the exit at Waterton Road. The next highest priority should be between N. Roxborough Drive and Raphael Lane from the corner of N. Roxborough Drive and Roxborough Drive in the south to the N. Roxborough Drive intersection with Dante Drive in the north. Reducing these shrub fuel loads should result in lower intensity, slower spread, reduced ember cast, and a lower probability of ignition resulting in more efficient evacuation along this route.

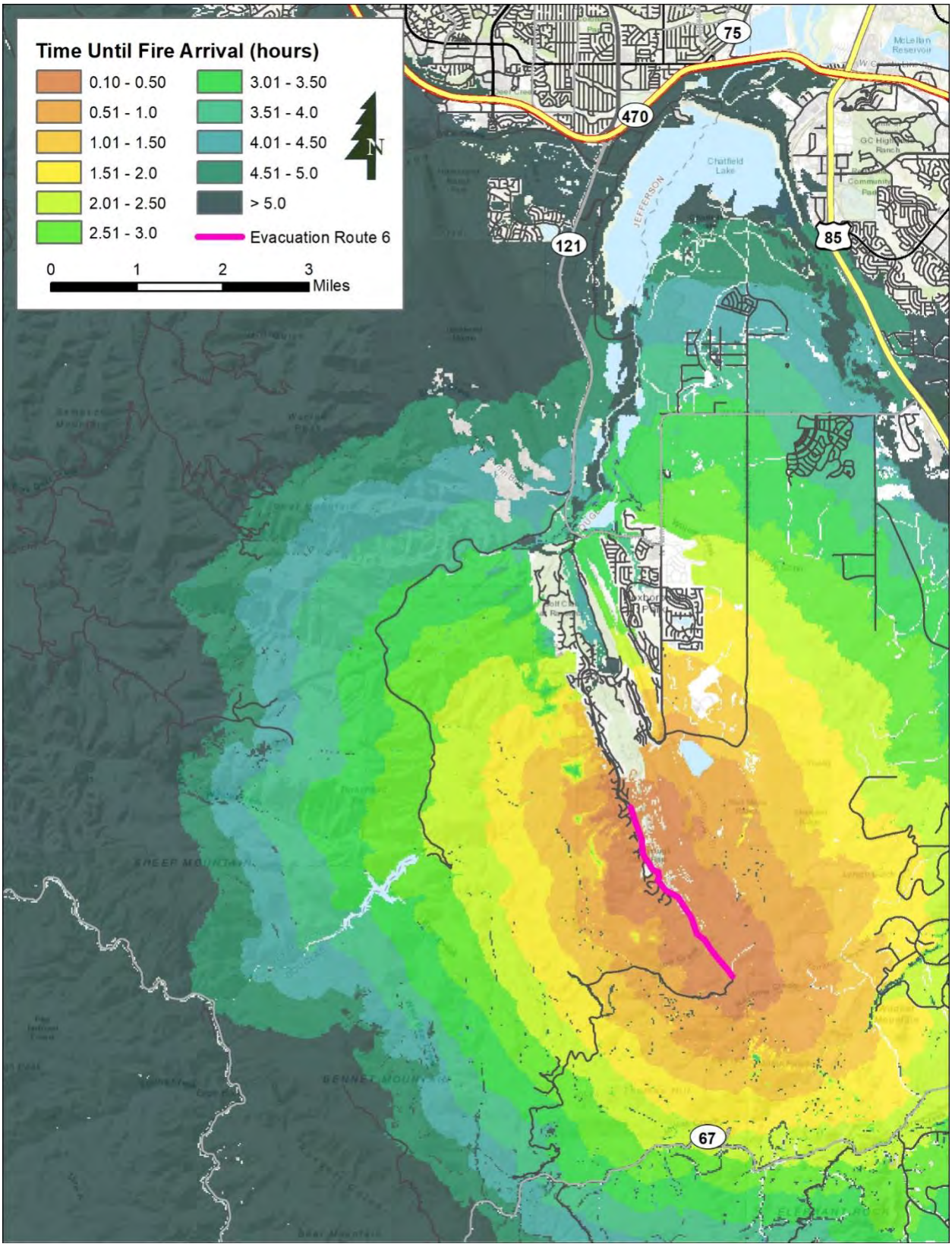


Figure 14, Evacuation Route 6, TUFA

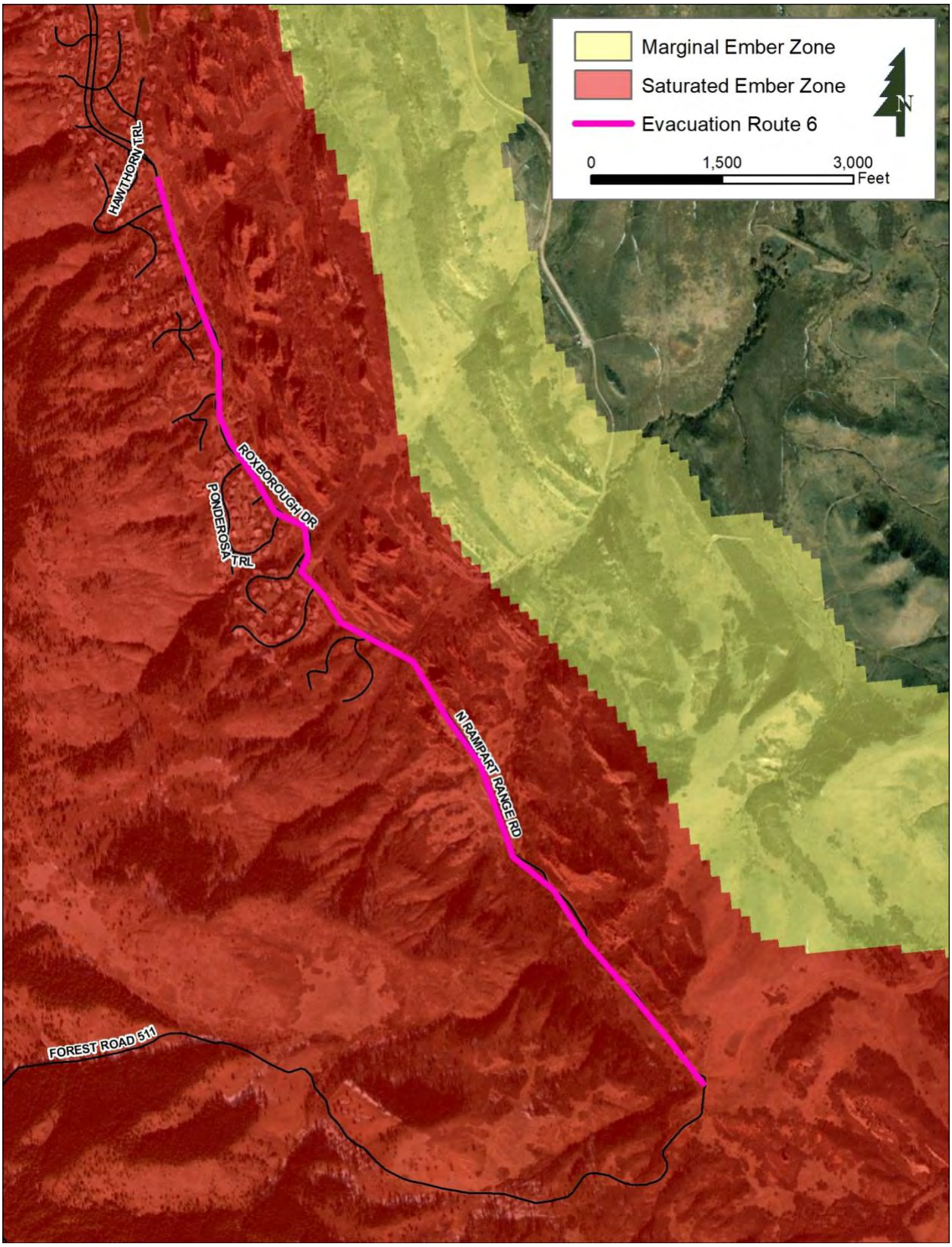


Figure 15, Evacuation Route 6, Ember Zones

EVACUATION ROUTE 6

Evacuation Route 6 is a continuation of Evacuation Route 4 going south rather than north. It runs from the southern end of Roxborough Drive along Iron Bark Road (old Douglas County Road 5), eventually coming out on C-67. This long, circuitous route is primarily dirt, and the portion immediately south of Roxborough Park goes through heavy fuels at the bottom of a canyon. There is no exit from the canyon other than to follow Iron Bark Road north or south. Fire coming from the west out of the Pike National Forest could make this a dangerous route.

This route requires several turns to reach C-67 from Roxborough Park that could be confusing to evacuees. All junctions between the gate at Roxborough Park and C-67 should be marked with signs similar to the one in Figure 1 indicating the proper direction of travel.

Since most of this route is dirt, surface conditions may be variable. This route should be checked at least a couple of times annually during the warm months to ensure it is suitable for passenger vehicles. Use for civilian evacuation during early spring and late fall when passage could be complicated by snow is not recommended; however, it could still be useful for responder access depending on conditions. In addition to surface concerns and potential route confusion, heavy fuels on both sides of this route are concerning. Although this entire route should be evaluated for roadside thinning, the highest priority area should be from the gate at Roxborough Drive to the junction where Iron Bark Road transitions from north/south to east/west.

Post Fire Debris Flow Modeling

The USGS *Emergency Assessment of Post-Fire Debris-Flow Hazards* web page begins with the following statement, "Wildfire can significantly alter the hydrologic response of a watershed to the extent that even modest rainstorms can produce dangerous flash floods and debris flows."[v] With post-burn conditions, it may only take a one to two-year rain event to generate the same water depth, velocity, and flow force that would result from a 50 to 100-year storm under pre-burn conditions.

Results of the debris flow analysis for the six evacuation routes modeled in this appendix are shown below. This analysis considers the predicted fire intensity, soil types, topography and the probability of significant rains following a fire event to determine areas at risk of a post-fire debris flow or flooding. Calculations for this analysis used the USGS landslide hazard program methods for emergency assessments assuming a two-year, 24-hour storm event which are the same parameters usually requested by CDOT. This is for a large storm expected to occur before the watershed recovers. Although this analysis generates several datasets, the final ranking has been simplified on the maps included in this appendix to show the evacuation routes in respect to areas expected to receive heavy, moderate, and low debris flows from such an event.

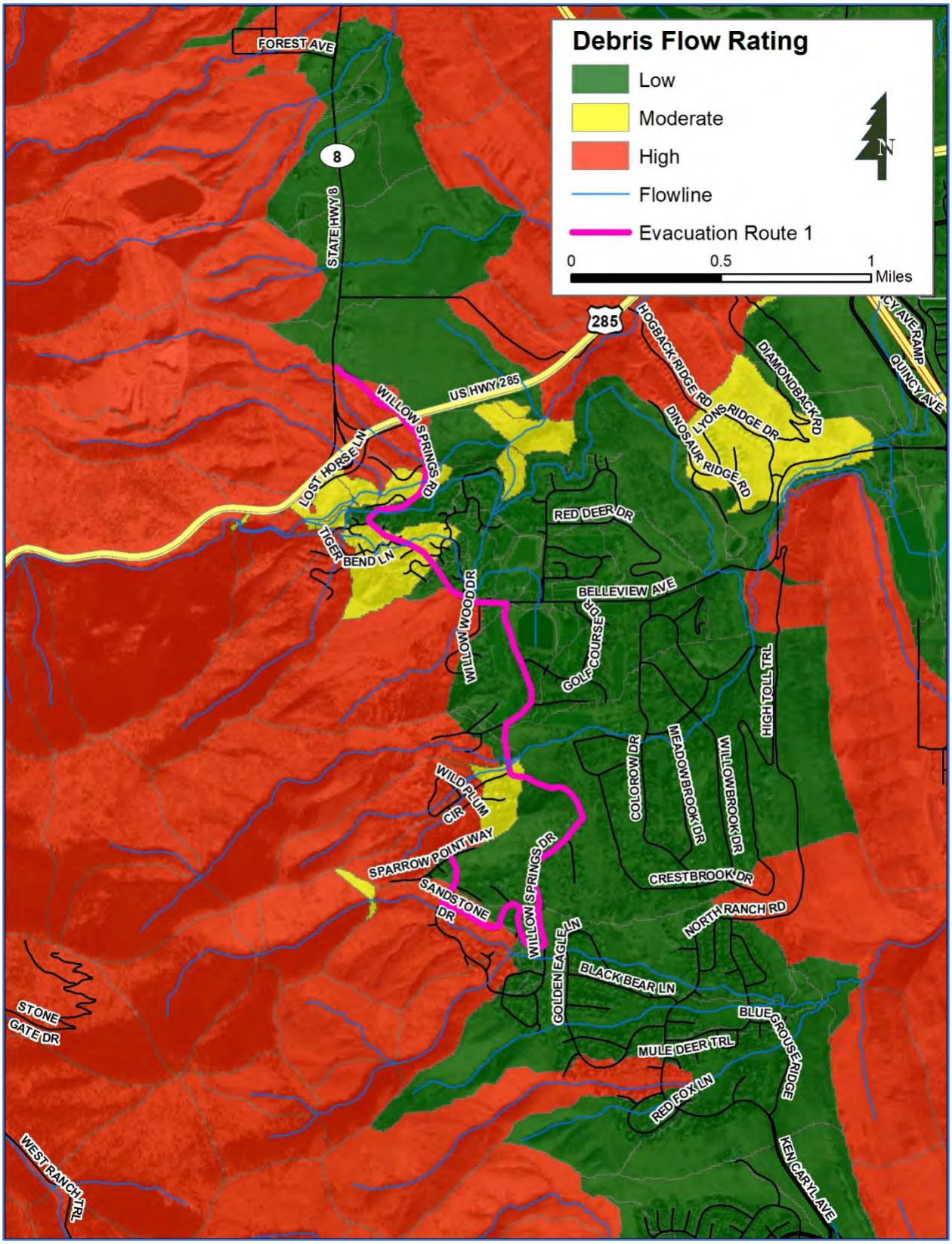


Figure 16, Evacuation Route 1, Post-Fire Debris Flow Analysis

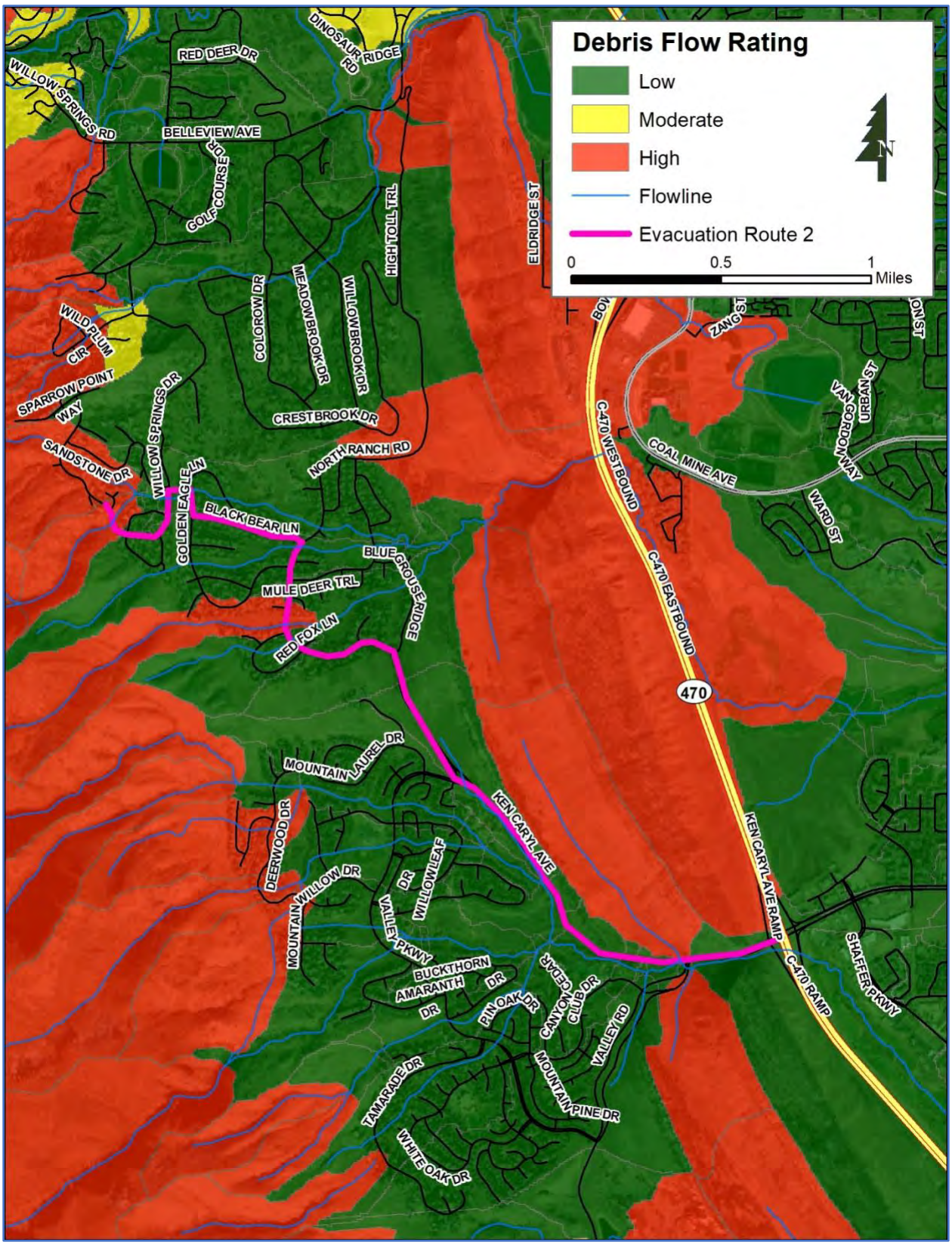


Figure 17, Evacuation Route 2, Post-Fire Debris Flow Analysis

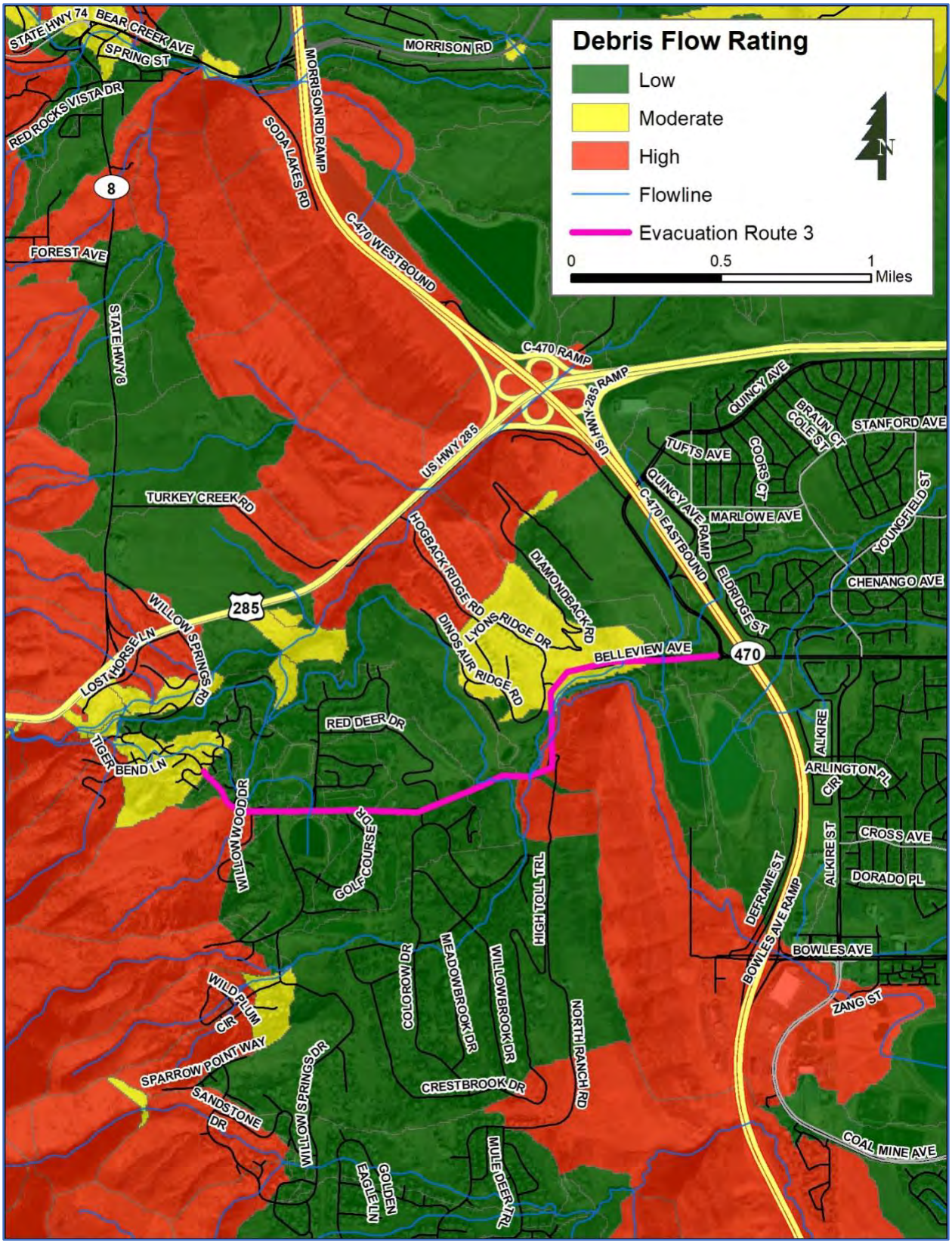


Figure 18, Evacuation Route 3, Post-Fire Debris Flow Analysis

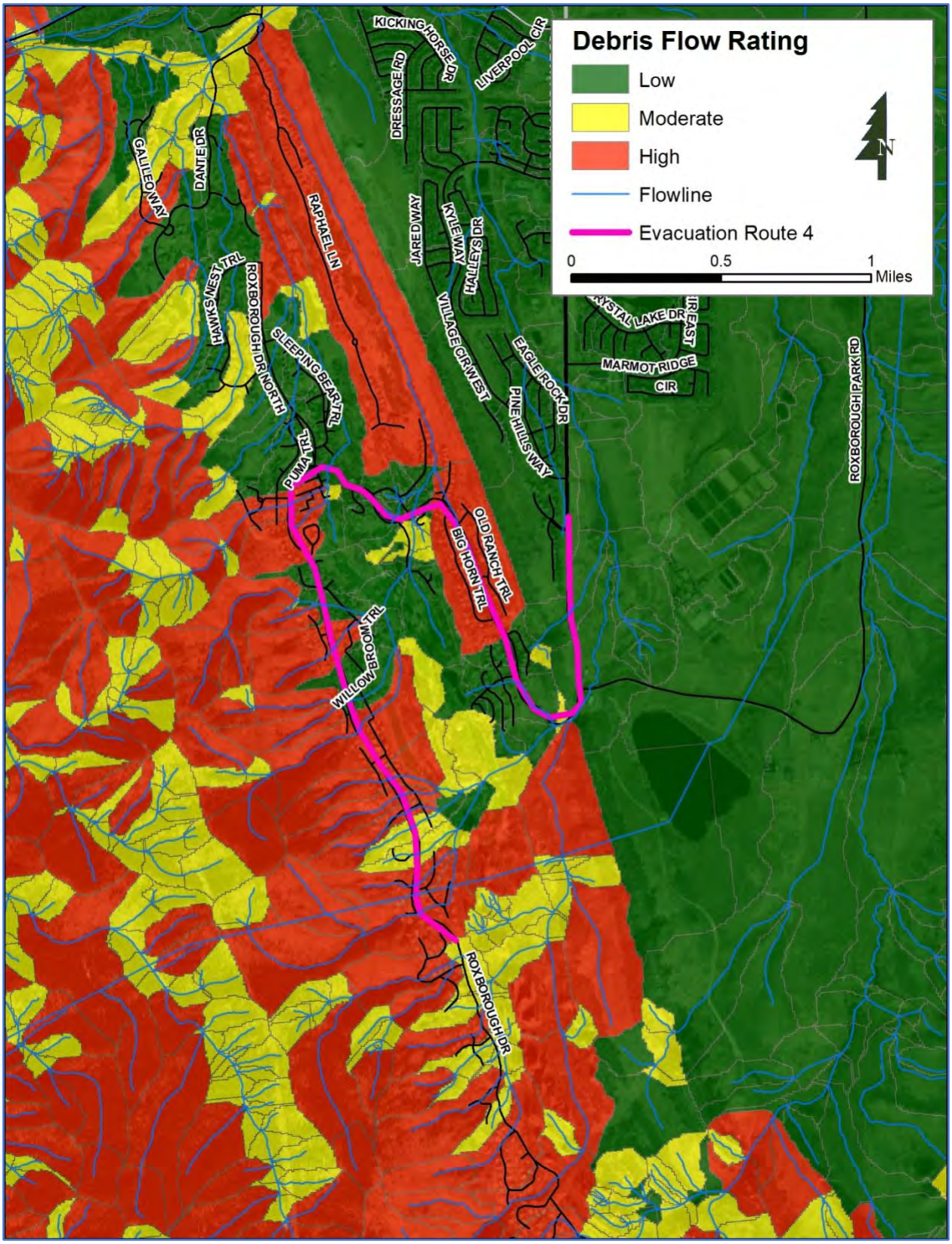


Figure 19, Evacuation Route 4, Post-Fire Debris Flow Analysis

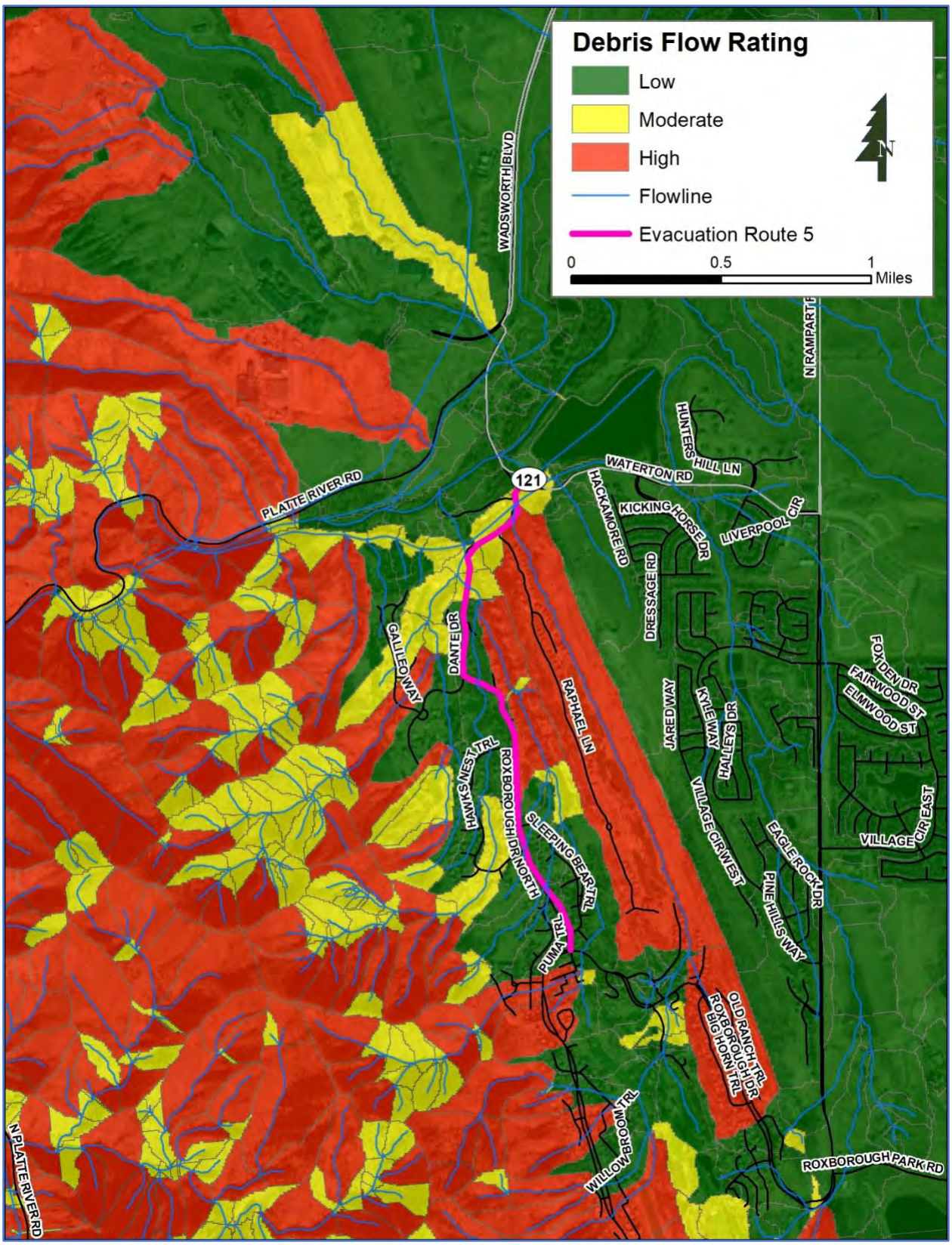


Figure 20, Evacuation Route 5, Post-Fire Debris Flow Analysis

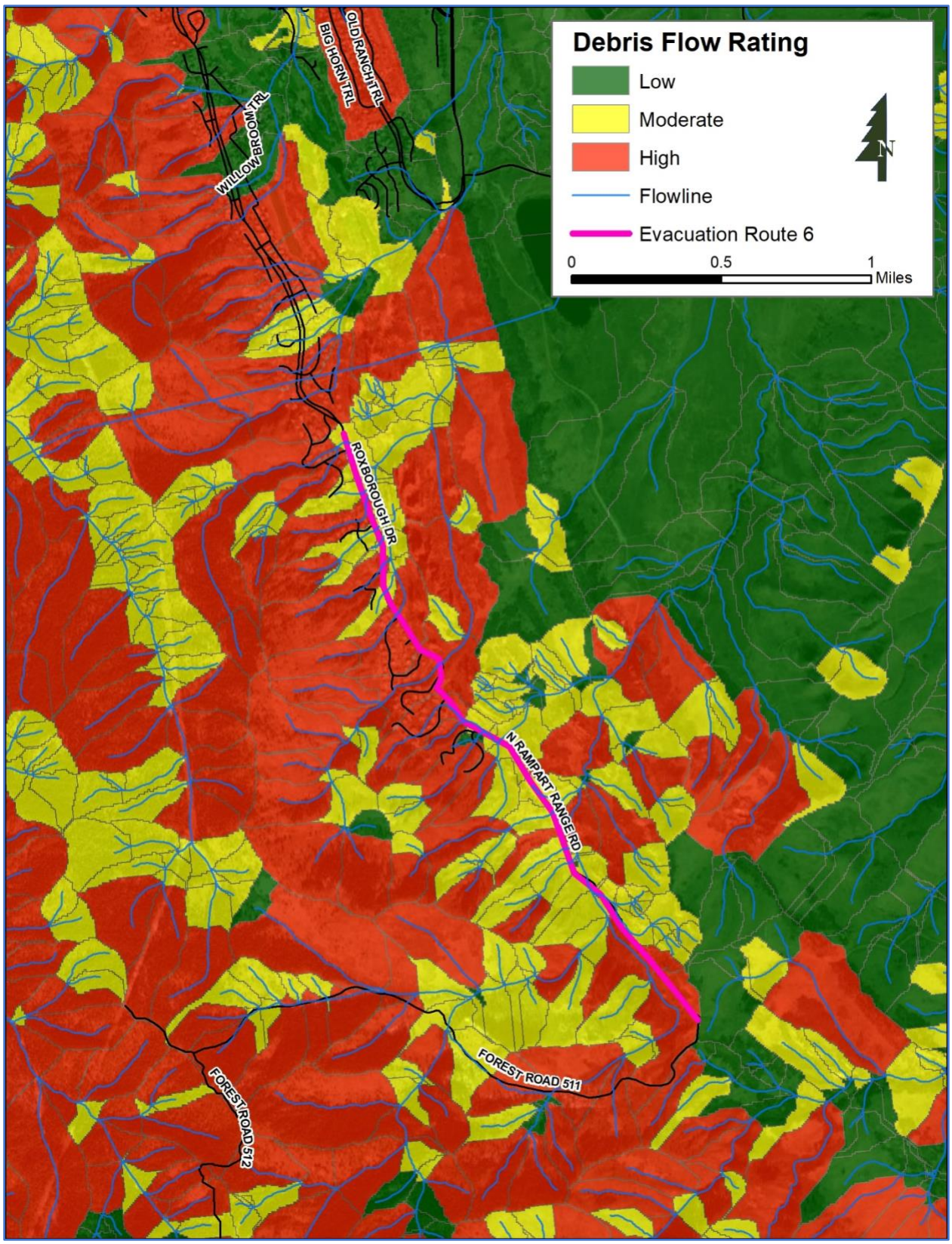


Figure 21, Evacuation Route 6, Post-Fire Debris Flow Analysis

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[iii] *Douglas County All-Hazards Evacuation, Alert and Warning Annex, An Annex of the Douglas County Comprehensive Emergency Management Plan* (Douglas County Office of Emergency Management, Douglas County Colorado, 2019), Page 153.
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WEST METRO FIRE DISTRICT

POST-FIRE FLOODING/ DEBRIS-FLOW POTENTIAL

DRAFT MEMORANDUM

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JUNE 21

RESPEC PROJECT NUMBER W0034

West Metro Fire District requested a high-level assessment of post-fire hydrologic hazards to help them identify and better prepare for potential impacts should a major wildfire occur within or upstream of the District. An analysis was conducted following the US Geological Service (USGS) Landslide Hazards Program's methodology for emergency assessment of post-fire debris-flow hazards, which the USGS typically conducts for communities downstream of burned areas following major wildfires. The emergency assessment uses empirical models to estimate the probability of post-fire debris-flow occurrence and debris-flow volumes for burned basins in response to a given design storm. The debris-flow prediction models spatially integrate information about burn severity, terrain, soil erodibility, and local precipitation patterns to consider the interdependence of these variables in post-fire storm response.

The debris-flow prediction models used in this analysis were developed using data from 388 basins impacted by 15 different wildfires in the Intermountain West and are shown in **Table 1** (Cannon et al. 2010). The USGS Landslide Hazards Program currently uses an updated model set for emergency assessments, developed using data from 1,243 basins burned by 34 fires throughout the western US (Gartner 2014 and Staley et al., 2016), However, this set was not used because it relies on the difference normalized burn ration (dNBR) rather than burn severity input variables, for which we do not have prediction methods. For this analysis, we followed USGS methods "for fires prior to 2016", as described in the program's scientific background documentation (https://landslides.usgs.gov/hazards/postfire_debrisflow/background2010.php).

Table 1: USGS Debris Flow Prediction Models

	Likelihood Model: $e^x/1+e^x$, where x =	**Volume Model (m^3): Ln (Volume) =**
Model	–0.7 + 0.03(%A) – 1.6(R) + 0.06(%B) + 0.07(I) + 0.2(C) – 0.4(LL)	7.2 + 0.6(ln A) + 0.7(B) 1/2 + 0.2(T) 1/2 + 0.3
Variables	Ab: % basin burned at moderate and high severities R: basin ruggedness (relief/area$^{1/2}$) C: % clay in soil I: average storm rainfall intensity (mm/hr) %A: % basin area with slope > 30% %B: % basin burned at moderate and high severities LL: soil liquid limit	S: basin area with slope > 30% (km^2) B: basin burned at moderate and high severities (km^2) R: total storm rainfall (mm) A: basin area with slope > 30% (km2) B: basin burned at moderate and high severities (km2) T: total storm rainfall (mm)

Stepping back to the earlier model set allowed for fire-behavior modeling results to serve as burn severity inputs, following methods developed by our team for the Cheyenne Municipal Watershed Wildfire Hazard Mitigation Assessment, which had three wildfires occur within the study area over the course of the project (RESPEC and Anchor Point, 2017). Soil burn severity was estimated by spatially correlating BAER soil burn severity maps of fires within the project area to the FlamMap fire-behavior modeling Fireline Intensity output dataset to determine critical thresholds on specific vegetation types (i.e., timber) that typically yield the moderate and high burn severity ratings observed on the ground by BAER teams to obtain a predicted soil burn severity estimate. These thresholds were applied to Fireline Intensity dataset developed for the WMFD project area to predict areas of moderate to high soil burn severity to be used as model inputs.

As shown in **Table 1**, the probability (likelihood) and severity (volume) of debris-flow occurrence is a function wildfire impacts (soil burn severity), as well as variables related to topography (ruggedness, slope), soil properties (clay, liquid limit), and precipitation (intensity, volume). Variables that describe the each subbasin's physical characteristics, such as slope relief, were acquired through USGS digital elevation models (DEMs).

Soil variables were obtained from the Natural Resource Conservation Service (NRCS) gridded National Soil Survey Geographic Database (gNATSGO), which combines data from the Soil Survey Geographic Database (SSURGO), State Soil Geographic Database (STATSGO2), and Raster Soil Survey Databases (RSS). Precipitation intensity and volume were obtained from NOAA Atlas14 for the 2-year design storm; the precipitation data was originally obtained at a 30 meter resolution and resampled to a 10 m grid. All other datasets were provided at a 10 meter resolution.

Because debris flow likelihood and volume are calculated for a specific drainage area, the area of concern (watersheds upstream from WMFD) were delineated to provide smaller drainage areas (catchments), and the mean values for each of the above-mentioned variables were spatially calculated using ArcGIS Pro. Catchment layers were obtained from the National Hydrology Dataset (NHD) for the Hydrologic Unit Code 10-digit (HUC10) watersheds that drain to the WMFD, including: 1019000203, Outlet North Fork South Platte River; 1019000206, West Plum Creek; 1019000207, Chatfield Reservoir-South Platte River; 1019000208, Bear Creek; 1019000209, City of Lakewood-South Platte River; and, 1019000404, Lower Clear Creek. Both the NHDPlus Version 2 and the NHDPlus High Resolution (NHDPlus HR) datasets were used to allow the debris-flow analysis to be run at multiple scales. The lower resolution NHDPlus Version 2 delineated approximately 700 catchments within the five HUC10 watersheds with an average size of 1360 acres; whereas, the higher resolution NHDPlus HR dataset contains over 25,000 catchments with an average size of 30 acres. Using both the lower and higher resolution NHD provide both a "big picture" and more detailed look at the areas expected to contribute large volumes of material downstream during post-fire storms.

The required debris flow model input variables were extracted each subbasin using zonal statistics in ArcGIS Pro, and the debris-flow probability and volume were calculated using the equations in **Table 1**. Debris-flow probability and volume were computed for each catchment using both the NHDPlus Version 2 and NHDPlus HR catchment layers. Then, the results from the probability and volume analyses were binned and integrated to determine a combined relative debris-flow hazard ranking for each catchment following methods used by USGS Natural Hazards Program and outlined in Cannon 2010. Probability results were binned into five equal intervals where 0-20% = 1, 20-40% = 2, 40-60% = 3, 60-80% = 4, and 80-100% = 5, and a rank of 1 to 5 (with 5 being the highest) was assigned to each of the probability classes. Volume results were binned according to order of magnitude, and a rank of 1 to 4 was assigned to each of the volume classes, where 0-1000 m^3 = 1, 1,000-10,000 m^3 = 2, 10,000-100,000 m^3 = 3, and > 100,000 m^3 = 4. The probability and volume class ranks were then added together to produce the combined relative hazard ranking for each catchment (with 9 being the highest combined hazard, indicating both a high probability of debris flow occurrence and high volume of material that can be potentially transported downstream).

Results from the probability, volume, and combined relative hazard rankings were appended to the NHD catchment layers attribute tables and provided in file geodatabase, along with the input variable datasets used to support the assessment (topography, soils, and precipitation). HUC10 and HUC12 watersheds and NHD flowlines were also included in the geodatabase to help identify flow paths and the potential for compounding hazards. Overlaying these datasets with the other information in the WMI can help WMFD determine where pour points from high hazard catchments intersect with (and potentially threaten) critical infrastructure, evacuation routes, and other values-at-risk.

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