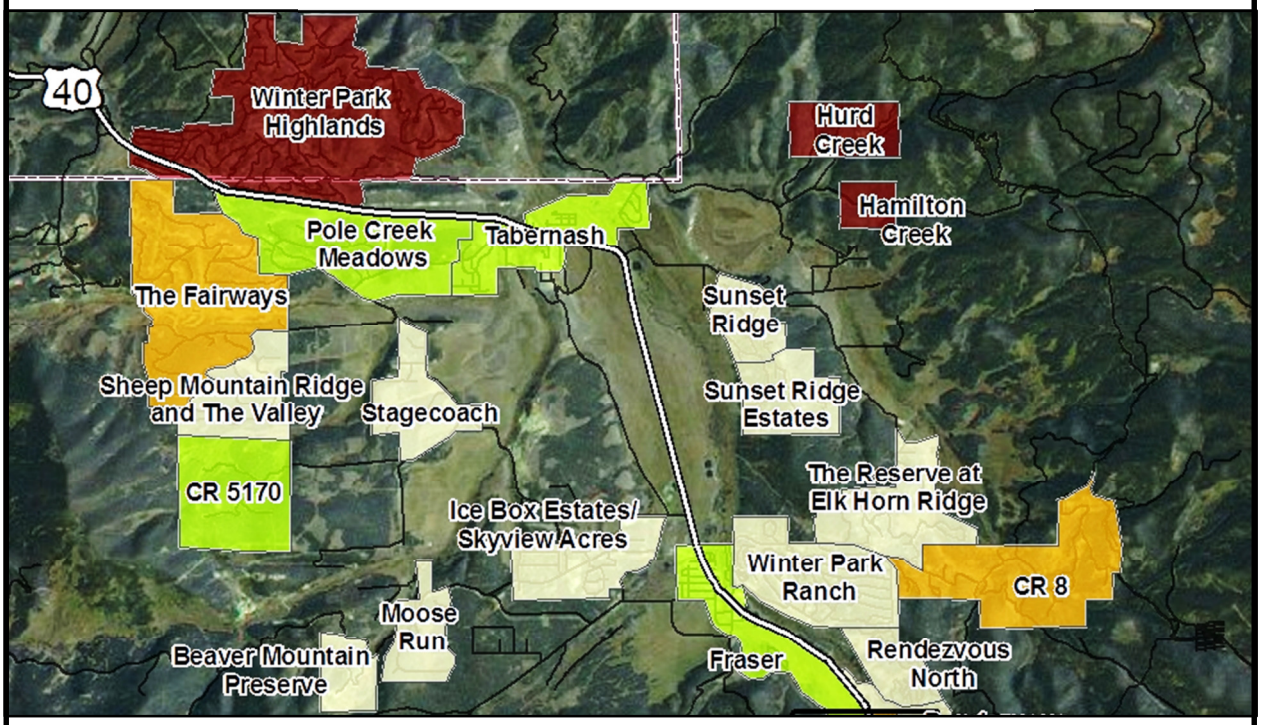
East Grand Fire Protection District No. 4 CWPP Update



October 2013

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COMMUNITY RATINGS UPDATE

The East Grand Fire CWPP was originally completed by Anchor Point in December of 2007. At that point, the mountain pine beetle epidemic had not yet reached its peak, and as a result, many of the identified and recommended treatments revolved around removal of beetle killed trees and smaller fuel breaks. Since the plan was completed, the Colorado State Forest Service and the USFS have completed over 30,000 acres of hazardous fuels reduction projects; many of which have been large-scale clear-cuts. Removal of the dead trees has greatly reduced the risk of wildfire to many of the communities identified in the CWPP, which is reflected in the modified hazard rating. However, even with massive amounts of fuel removal, some communities are still rated as extreme and very high because of the infrastructure (roads, power lines, lack of water, building materials), topography, and remaining fuels. Before any work had been completed, the forested areas around the communities were continuous stands of lodgepole pines, in various stages of the mountain pine beetle attack. Some were still green, while many had entered the 'red-needle' phase, where they are capable of igniting three times faster than green trees. A few were in the 'grey' stage, meaning they had lost their needles and were standing dead. With the removal of these trees, additional water and light has been able to reach the forest floor. This has given grasses and forbs an opportunity to flourish and take over. If they dry out, a fire in the light flashy fuels will be easier to contain, but would have a faster rate of spread. In areas where the trees are still standing, they still pose a threat in terms of wildfire as well as a fall hazard.

During the original CWPP, an Annual Work Plan was also developed, which gave detailed information on projects identified in the CWPP. There are graphics in this update, which accompany the community write-ups. For a full description of each community, please see the original CWPP document. Except for the fuels, there have been few changes to the infrastructure in the communities.

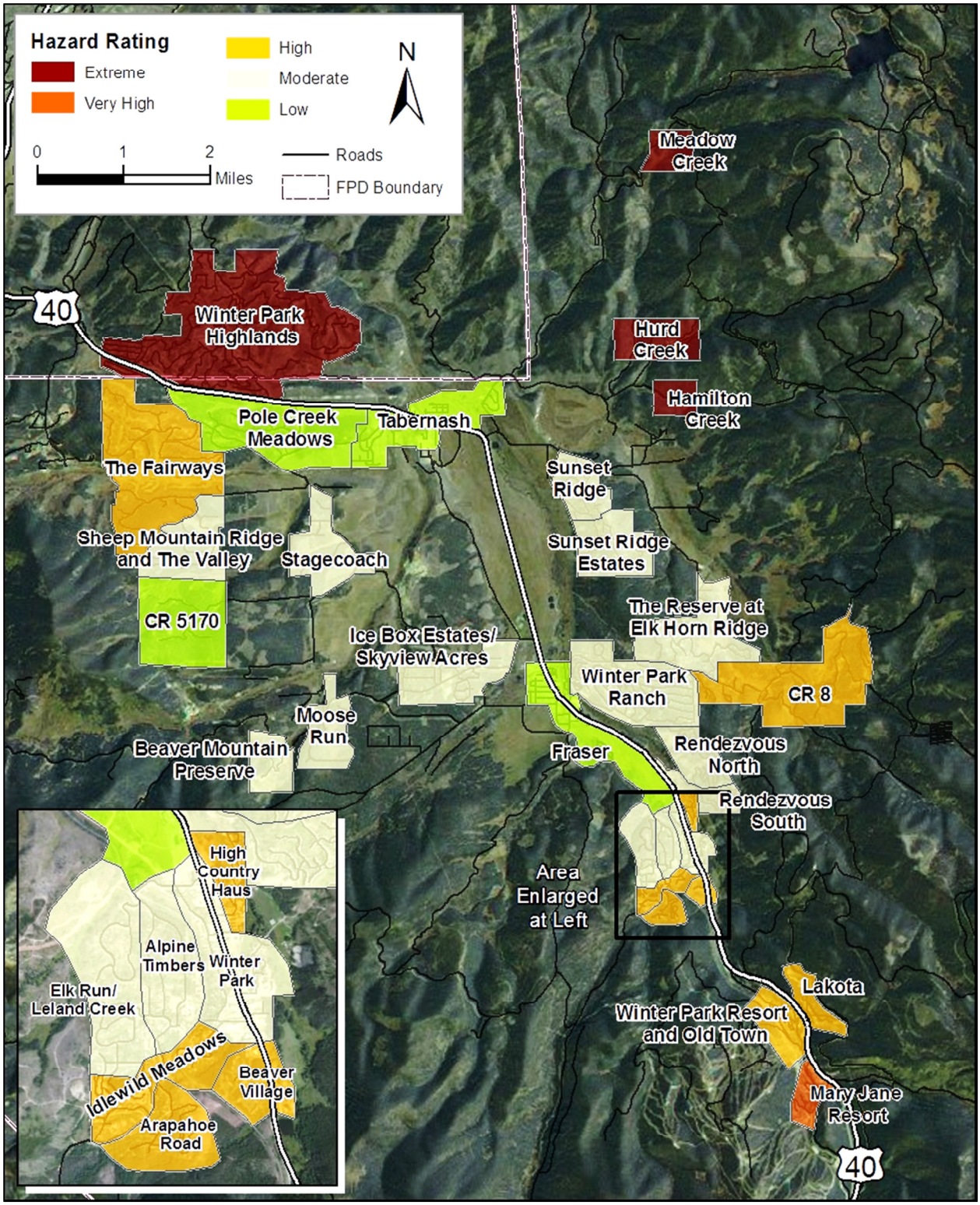

Figure 1. Overview of communities and hazard ratings for East Grand FPD.

1. Hurd Creek

Hazard Rating:	**Extreme**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	No
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	None
Hazards:	Steep slopes, ravines, inadequate roads, inadequate water supply, power lines, propane tanks, wooden roofs

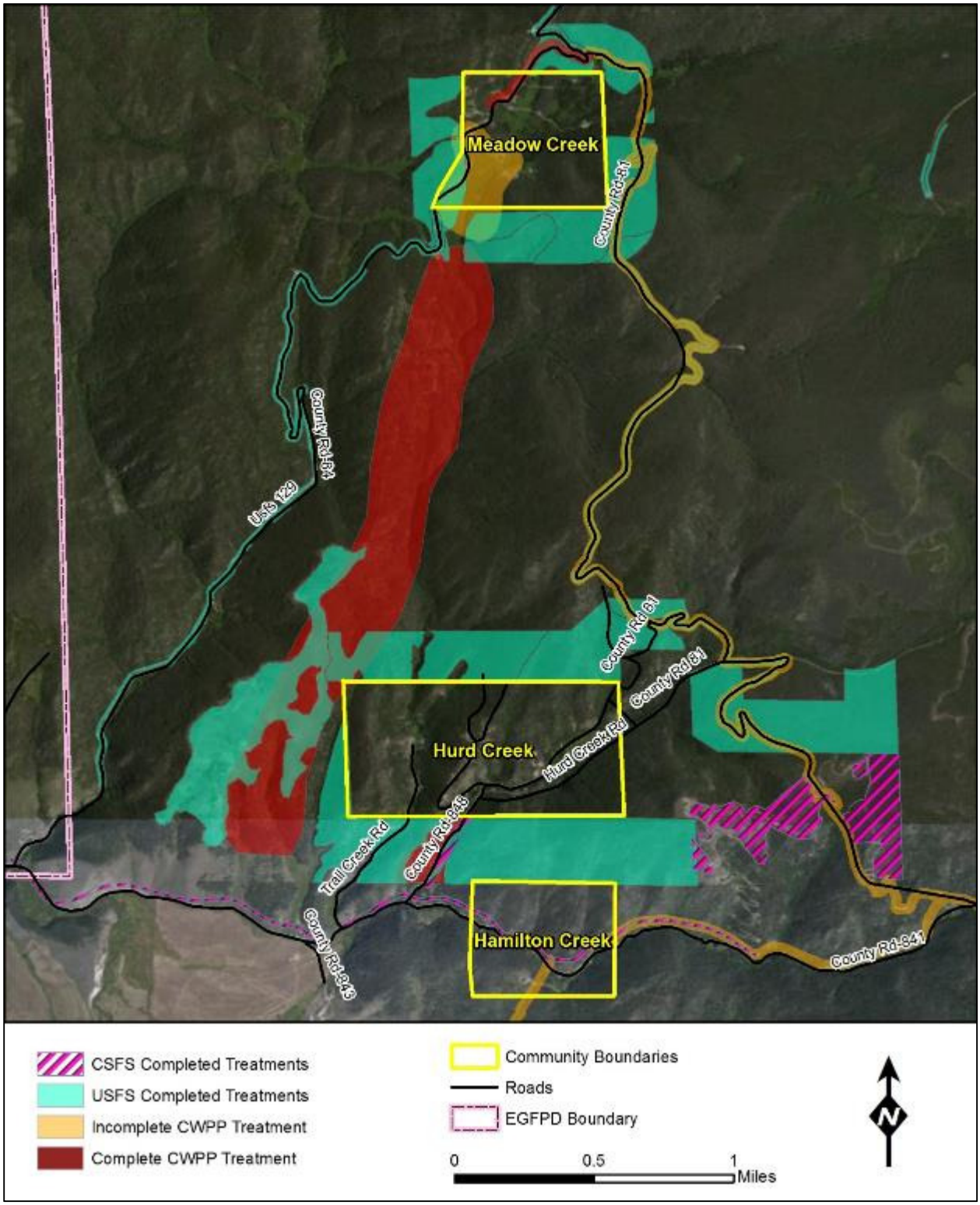

Figure 2. Completed and recommended fuel treatments for Hurd Creek.

2. Winter Park Highlands

Hazard Rating:	**Extreme**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	No
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	Draft hydrant on pond, 30,000 gal. cistern in progress
Hazards:	Steep slopes, ravines, inadequate roads, propane tanks, power lines, wooden roofs

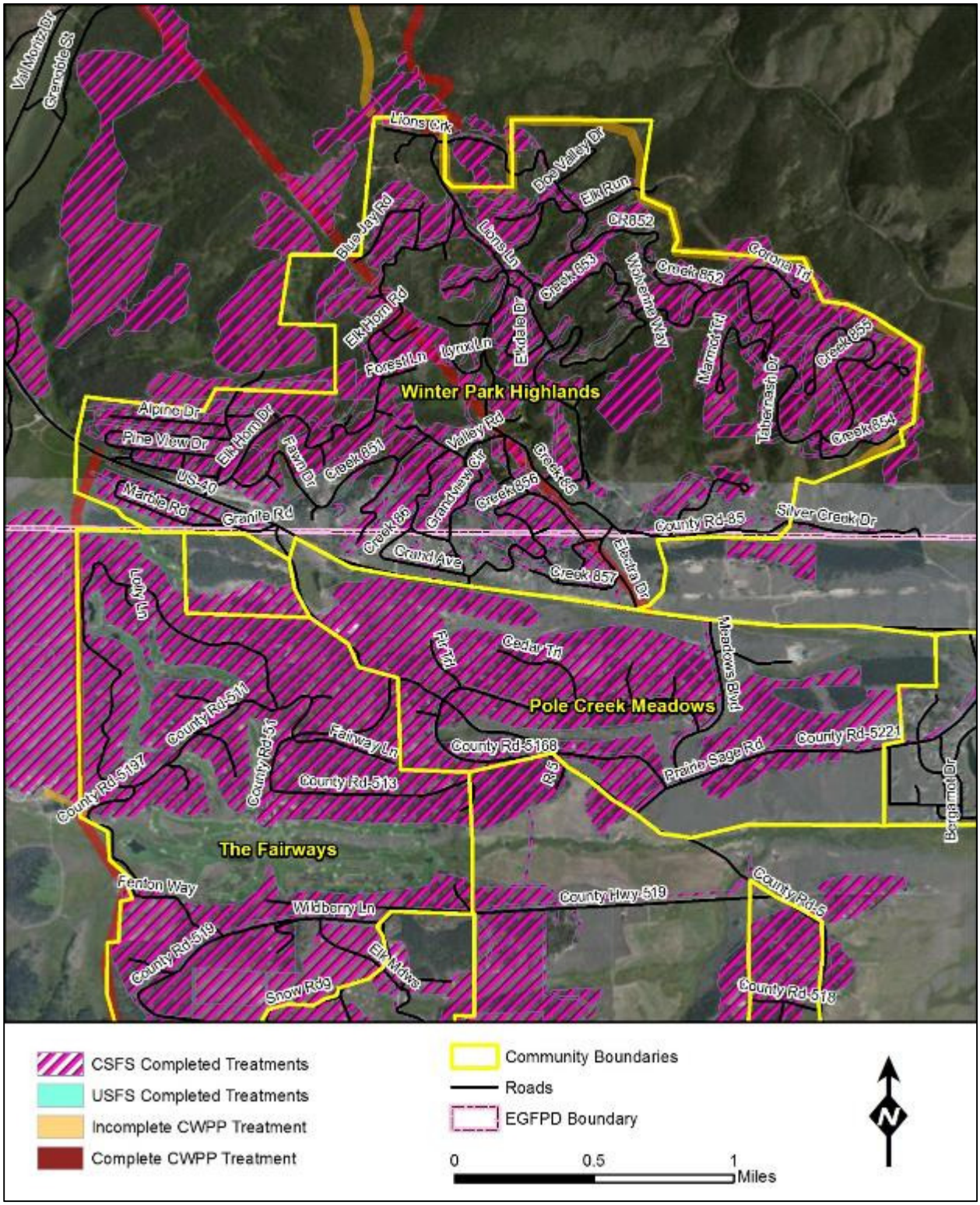

Figure 3. Completed and recommended fuel treatments for Winter Park Highlands.

3. Meadow Creek

Hazard Rating:	**Extreme**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	No
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	None
Hazards:	Steep slopes, inadequate roads, no water supply, wooden roofs, power lines, propane tanks

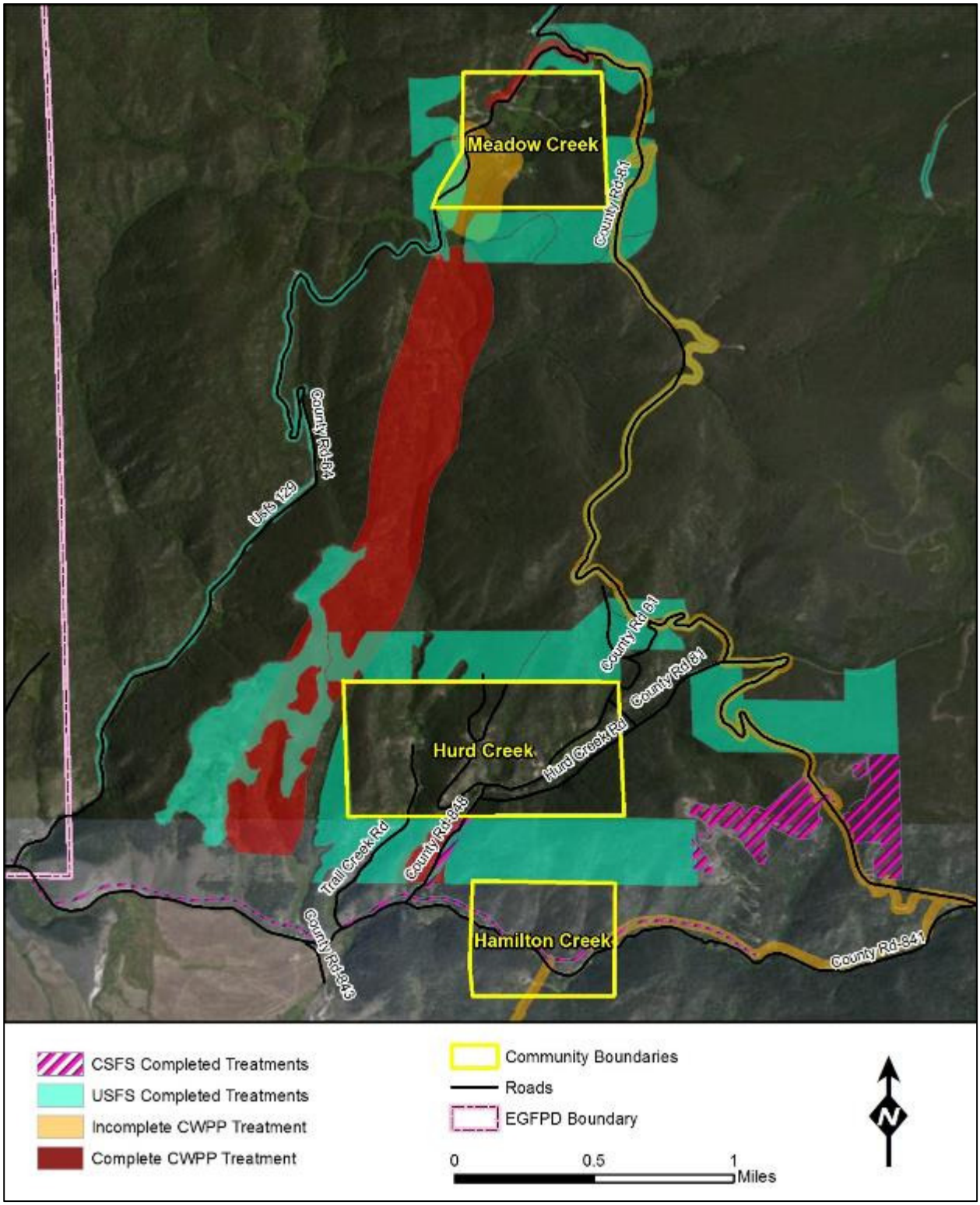

Figure 4. Completed and recommended fuel treatments for Meadow Creek.

4. Hamilton Creek

Hazard Rating:	**Extreme**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	No
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	Draft from creek
Hazards:	Steep slopes, ravines, inadequate roads, inadequate water supply, power lines, propane tanks

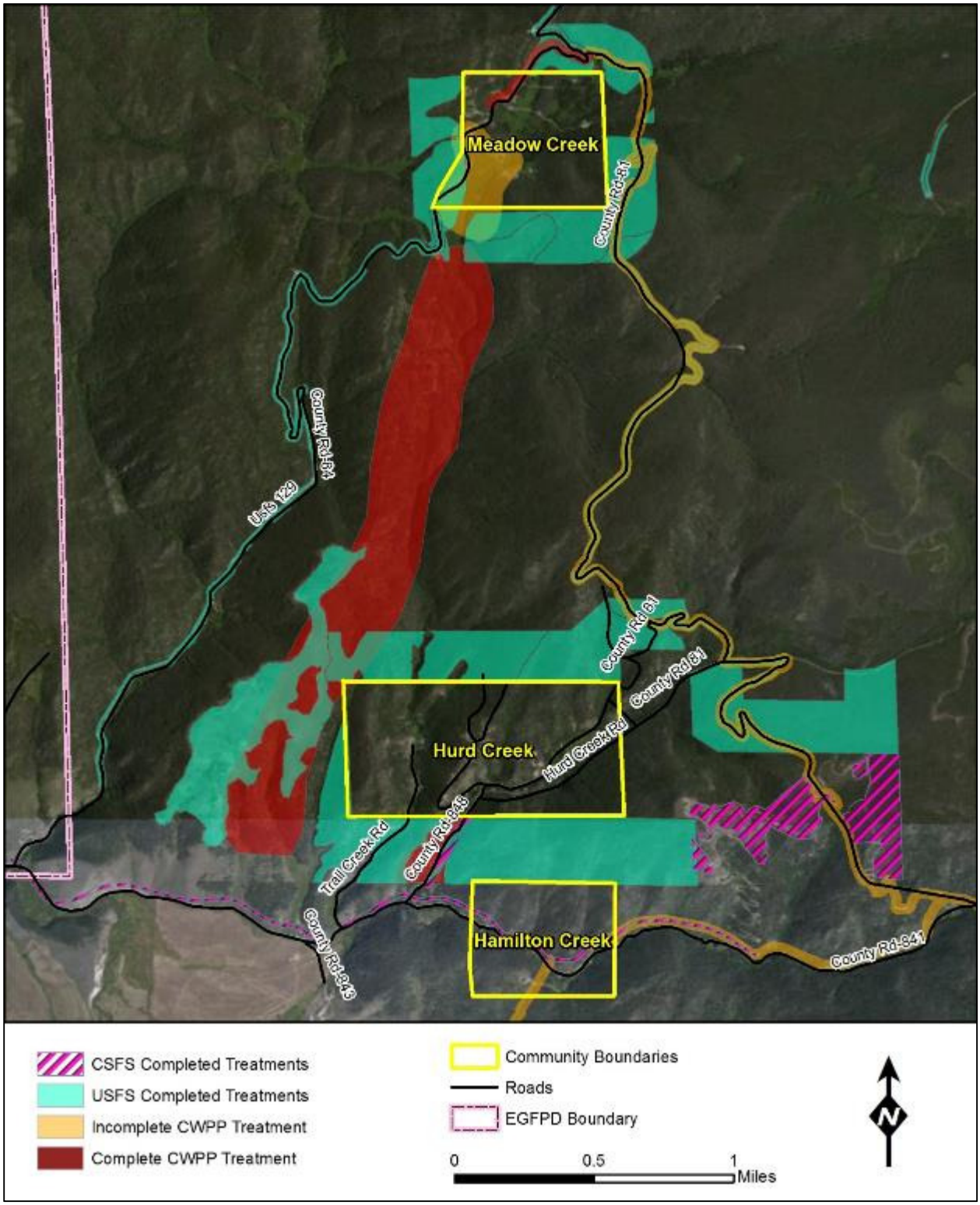

Figure 5. Completed and recommended fuel treatments Hamilton Creek.

5. CR 8

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	No
Are all access roads of adequate width?	No
Average lot size:	>5 Acres
Water supply:	None
Hazards:	Steep slopes, ravines, inadequate access roads, propane tanks, power lines

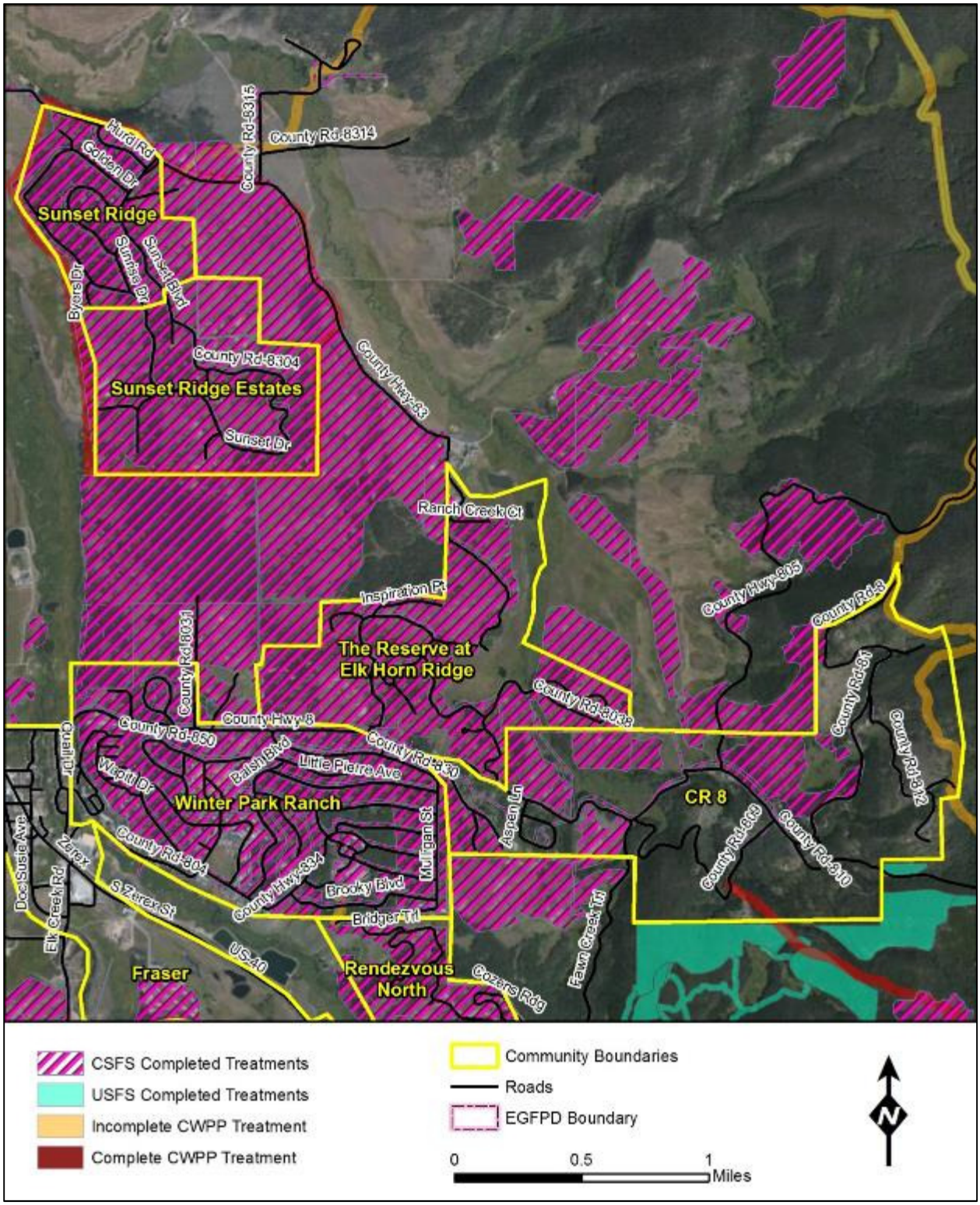

Figure 6. Completed and recommended fuel treatments for CR 8.

6. Arapahoe Road

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Steep slopes, ravines, inadequate roads, power lines, wooden roofs

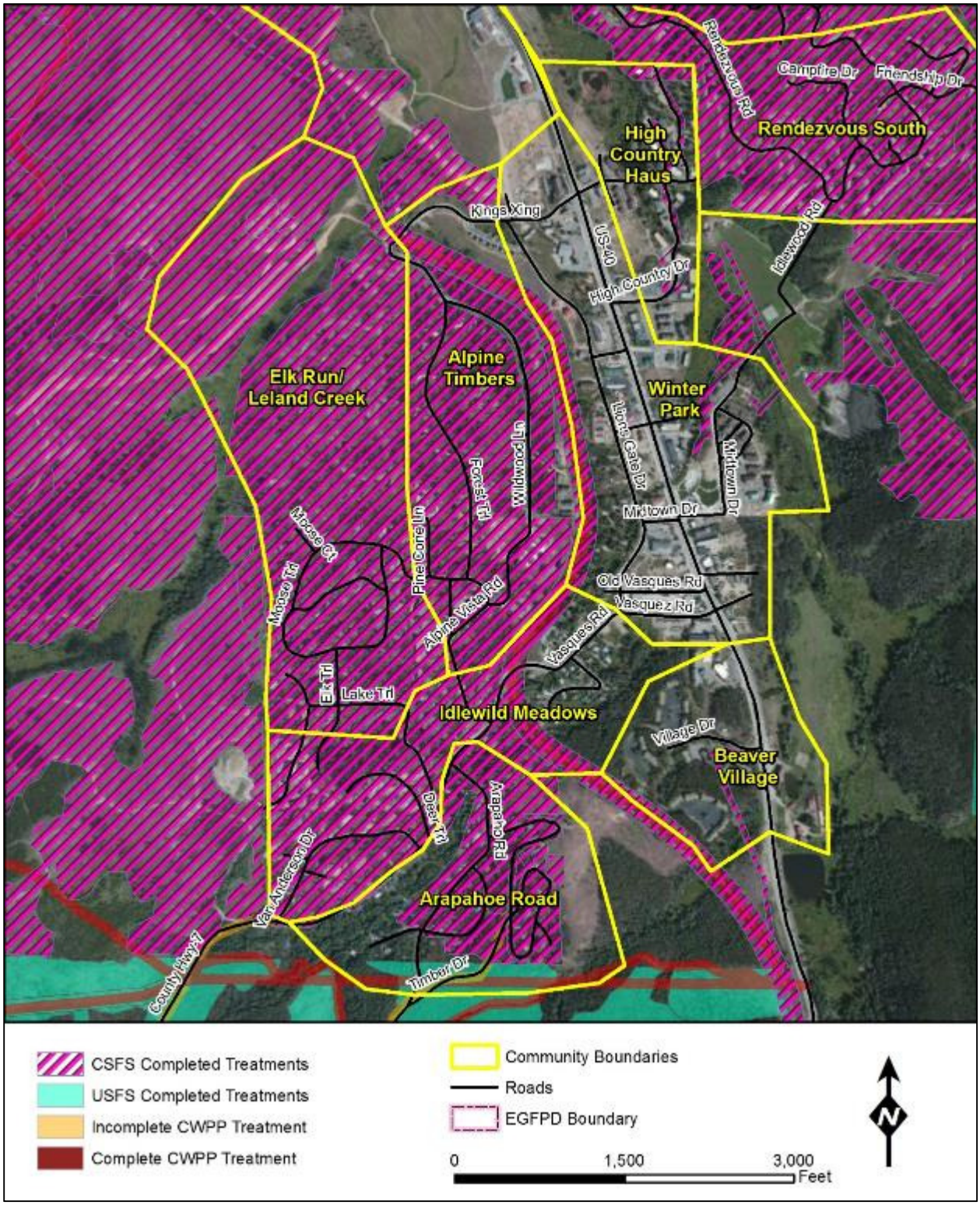

Figure 7. Completed and recommended fuel treatments Arapahoe Road.

7. Lakota

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Ravines, steep slopes

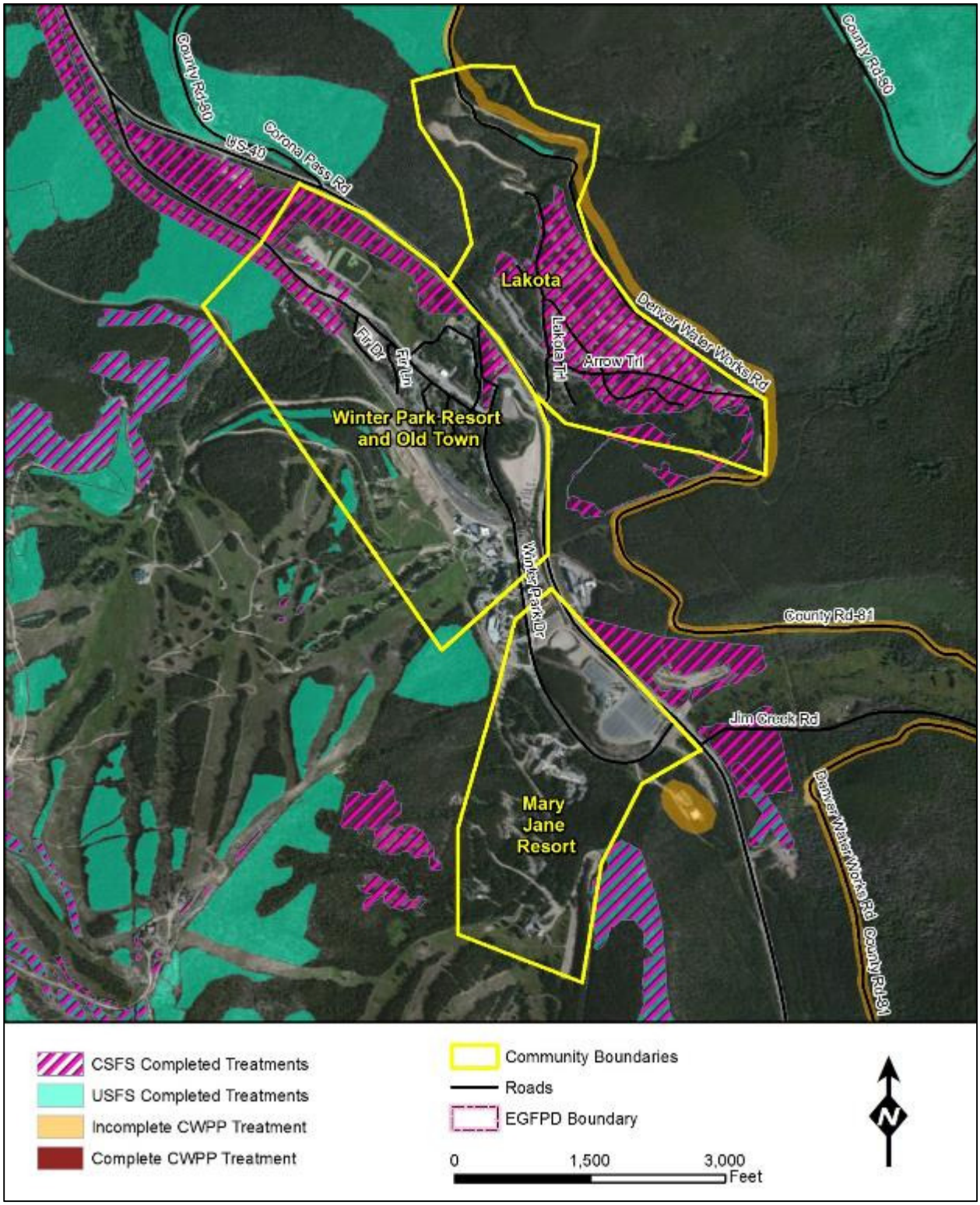

Figure 8. Completed and recommended fuel treatments for Lakota.

8. Mary Jane Resort

Hazard Rating:	**Very High**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Steep slopes, ravines

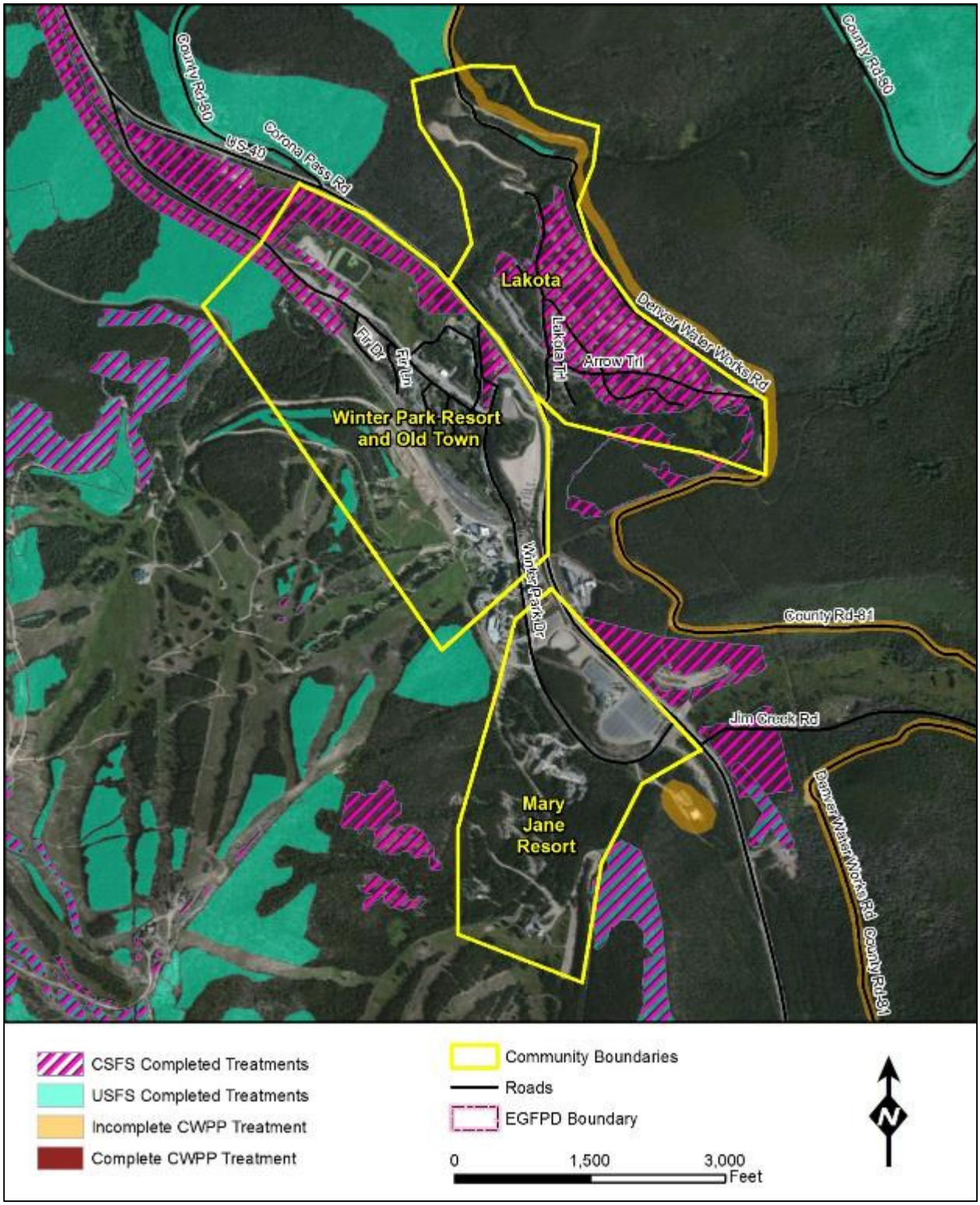

Figure 9. Completed and recommended fuel treatments for Mary Jane Resort.

9. Winter Park Ranch

Hazard Rating:	**Moderate**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	No
Are all access roads of adequate width?	No
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Steep slopes, ravines, power lines, wooden roofs

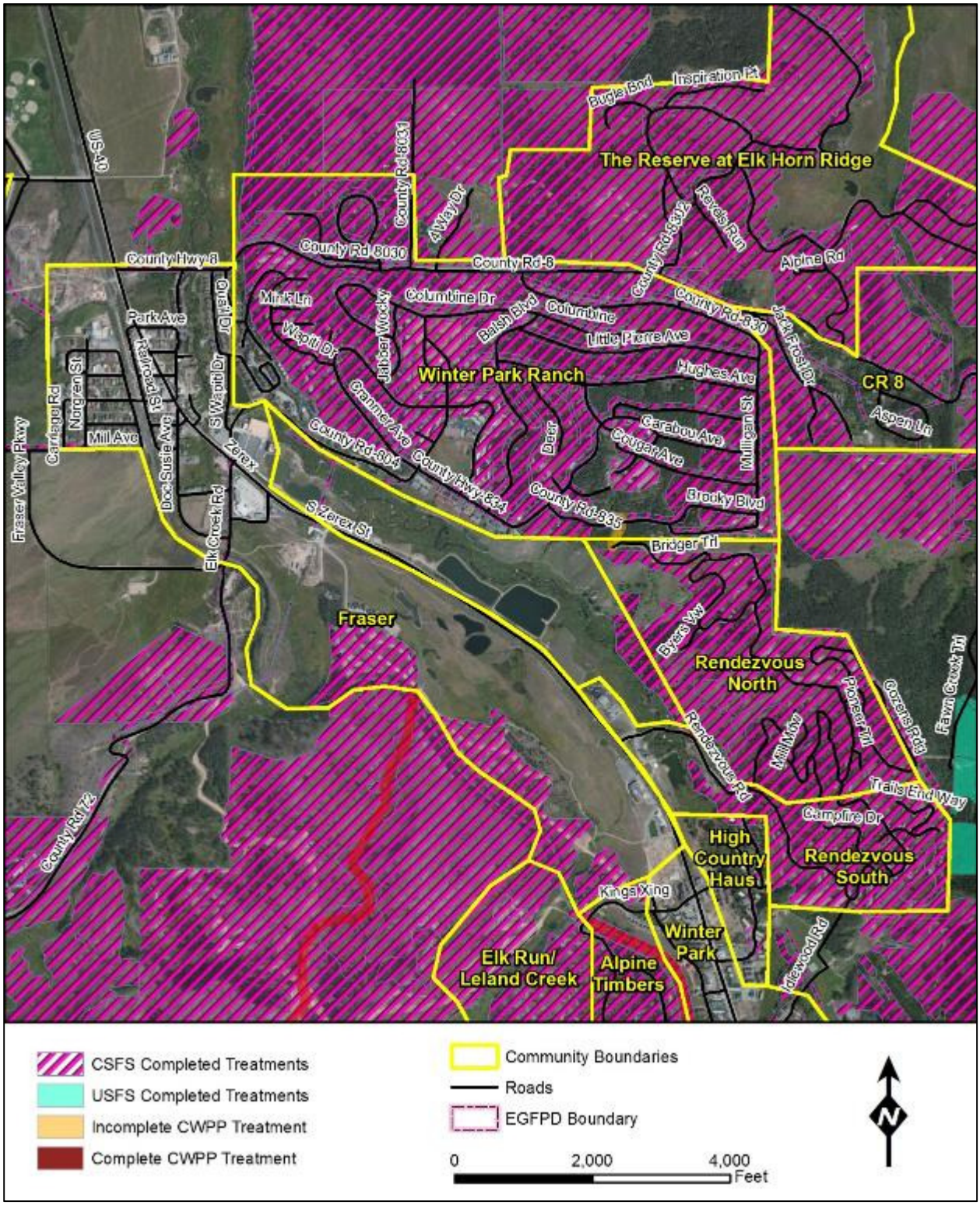

Figure 10. Completed and recommended fuel treatments for Winter Park Ranch.

10. Beaver Village

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Steep slopes, power lines

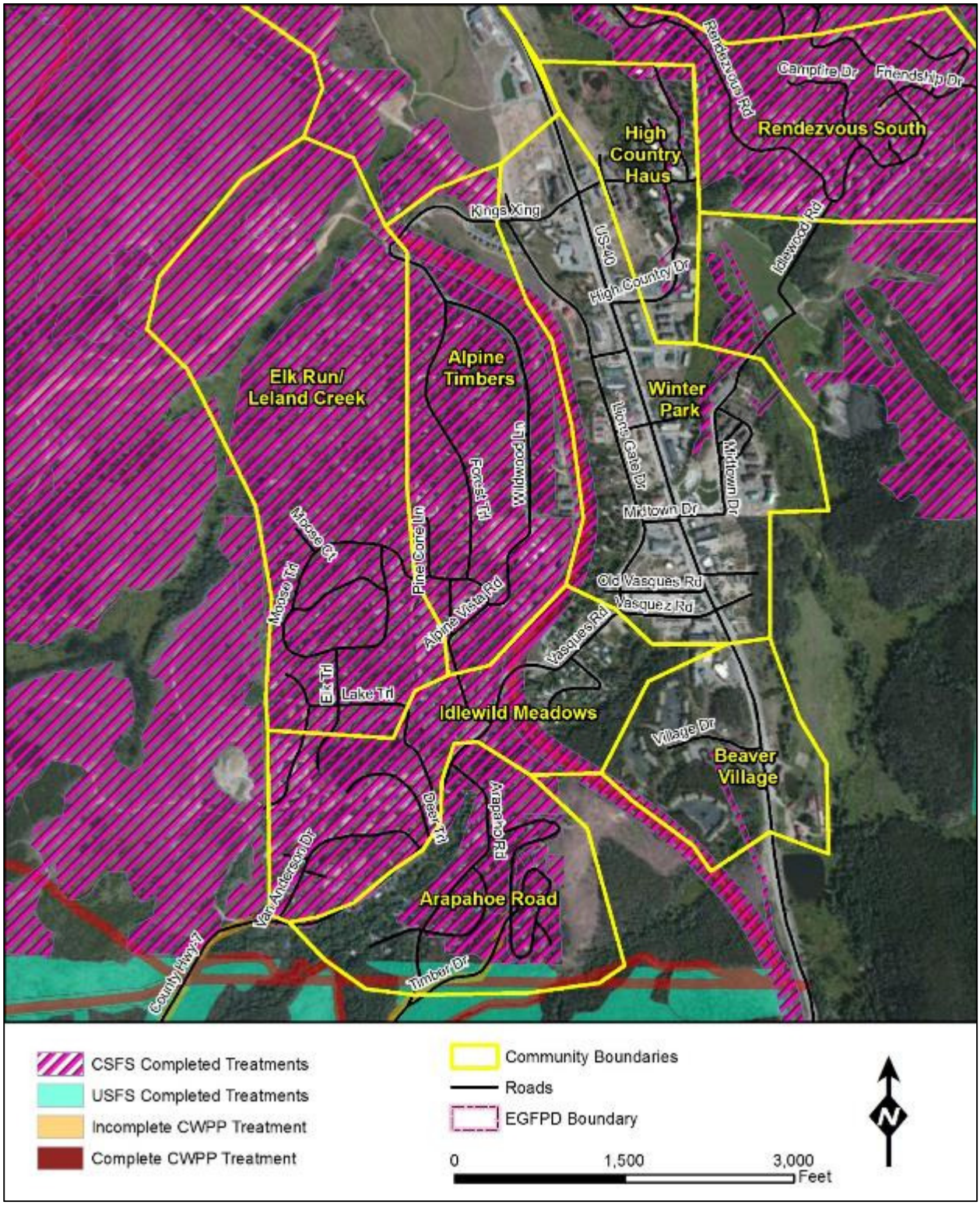

Figure 11. Completed and recommended fuel treatments for Beaver Village.

11. Winter Park Resort and Old Town

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	< 1 Acre
Water supply:	Hydrants
Hazards:	Steep slopes, inadequate access roads, wooden roofs

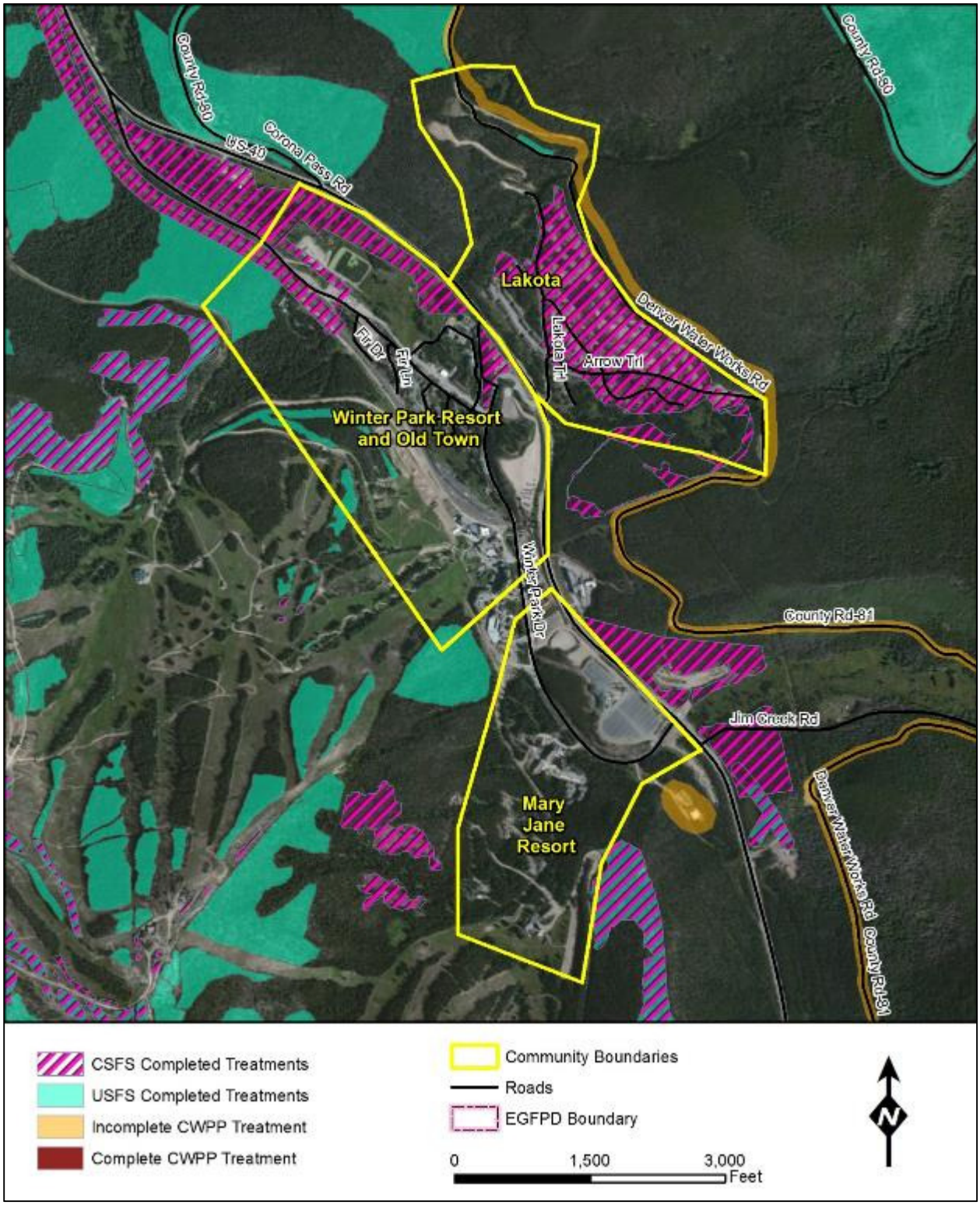

Figure 12. Completed and recommended fuel treatments for Winter Park Resort and Old Town.

12. The Reserve at Elkhorn Ridge

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	No
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Water supply:	One dry hydrant, ponds and authorization to use one hydrant on CR 8
Hazards:	Steep slopes, ravines, homes in saddles

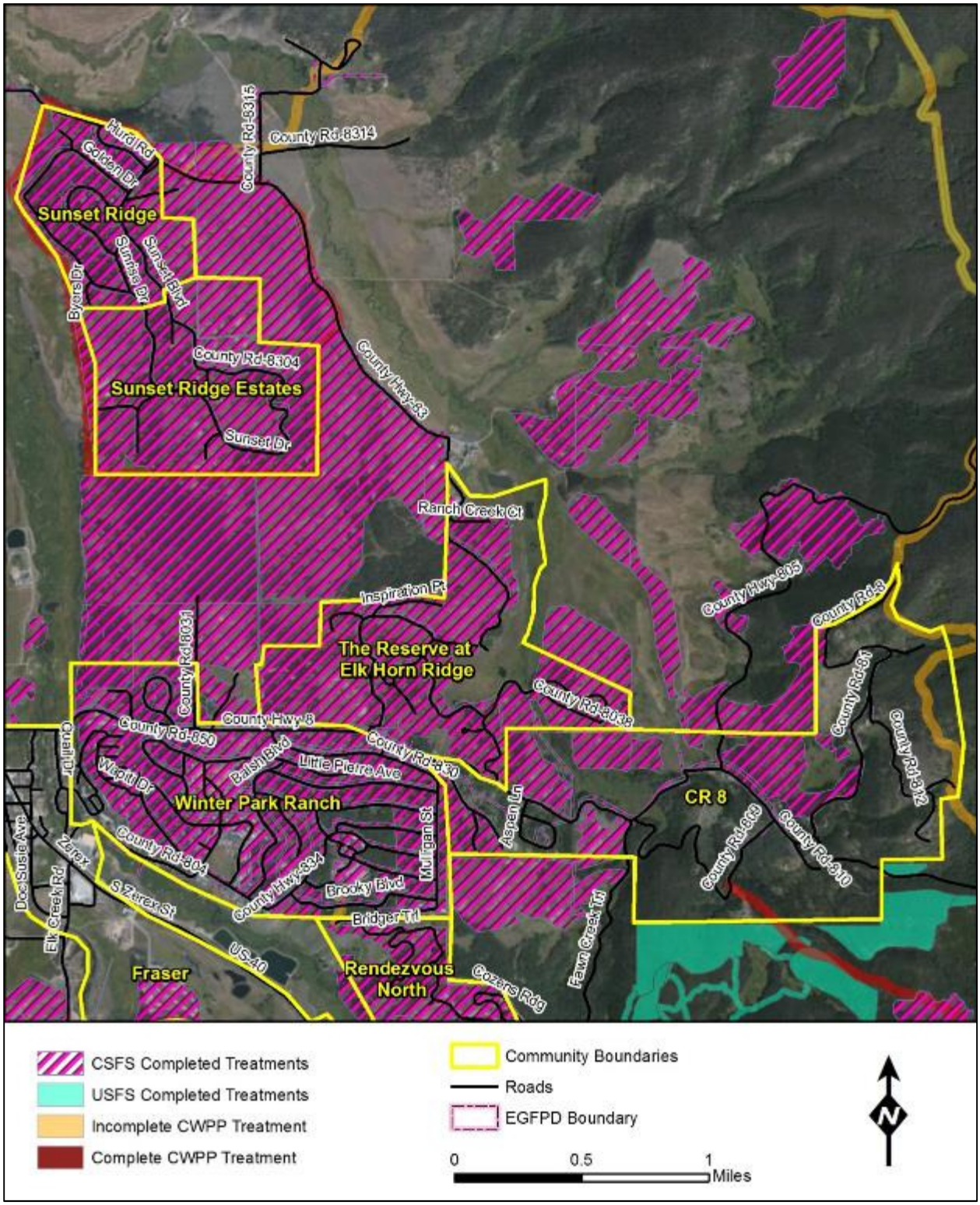

Figure 13. Completed and recommended fuel treatments for The Reserve at Elkhorn Ridge.

13. Beaver Mountain Preserve

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	> 5 Acres
Water supply:	One cistern (10,000 gallons)
Hazards:	Ravines, steep slopes, inadequate roads

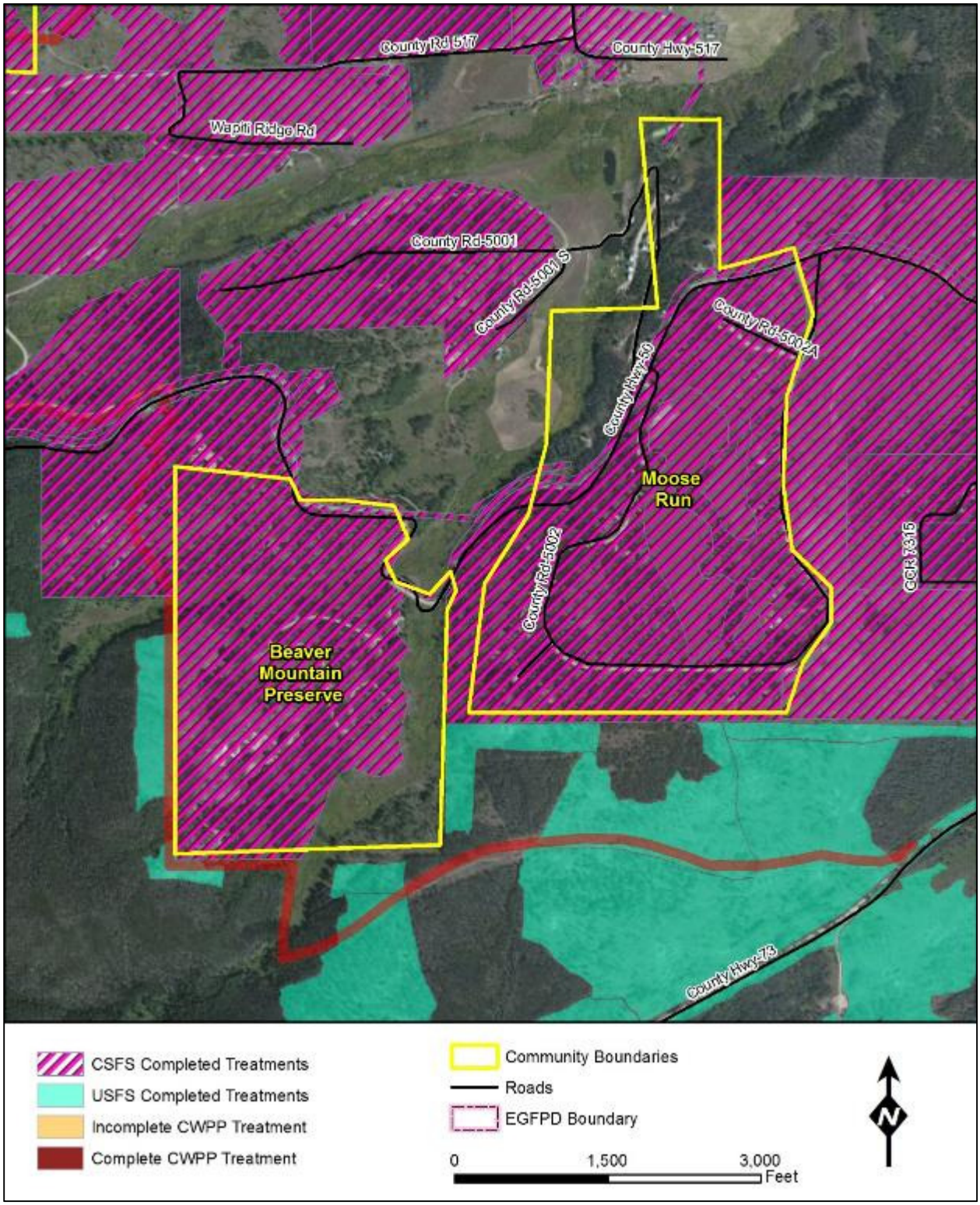

Figure 14. Completed and recommended fuel treatments for Beaver Mountain Preserve.

14. Rendezvous North

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	Hydrants
Hazards:	Steep slopes, ravines, inadequate roads, homes in saddles

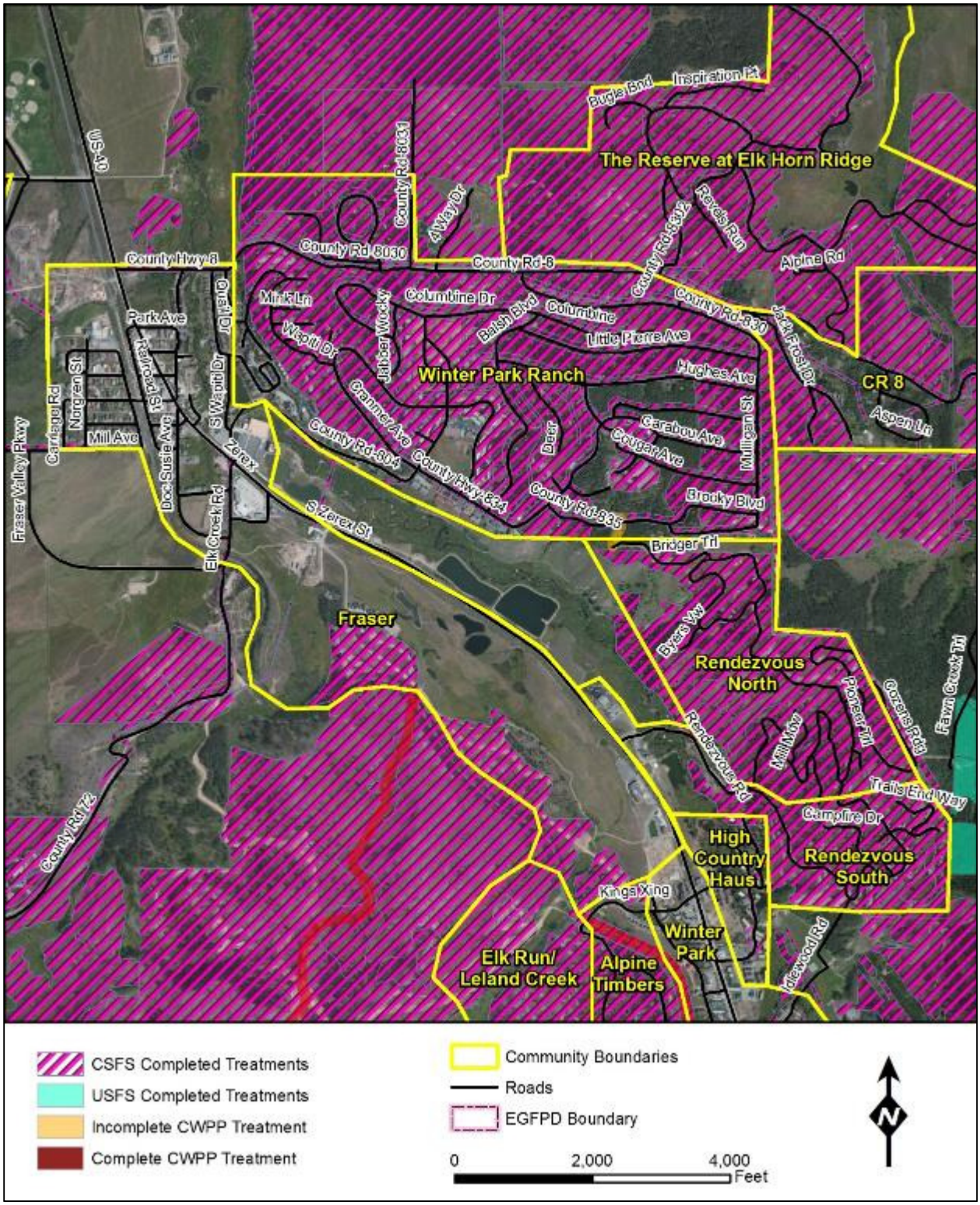

Figure 15. Completed and recommended fuel treatments for Rendezvous North.

15. Idlewild Meadows

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	<1 Acres
Water supply:	Hydrants
Hazards:	Power lines, propane tanks, ravines, wooden roofs

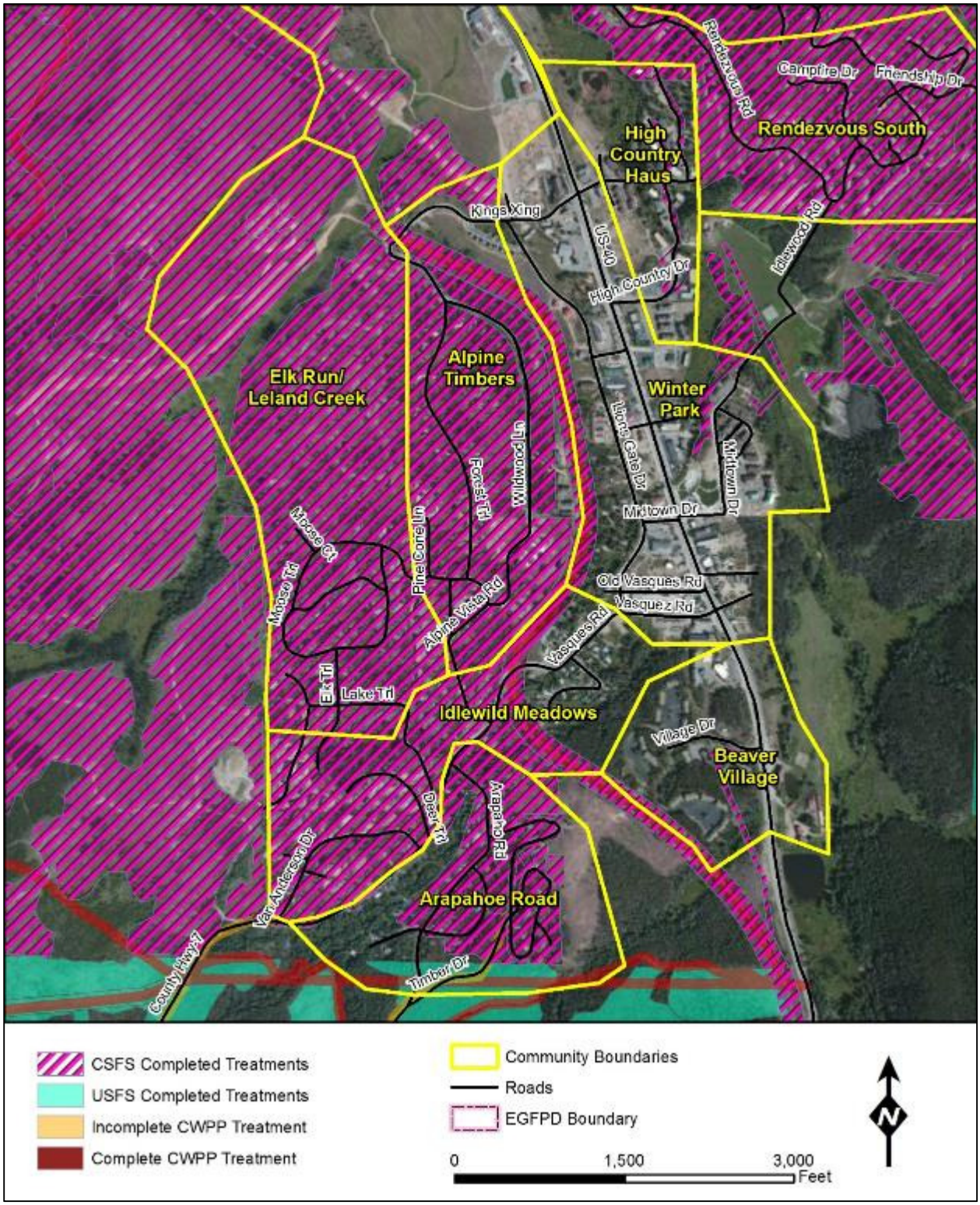

Figure 16. Completed and recommended fuel treatments for Idewild Meadows.

16. Rendezvous South

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acres
Fuel models found in the neighborhood:	1, 8, 10
Water supply:	Hydrants
Hazards:	Ravines

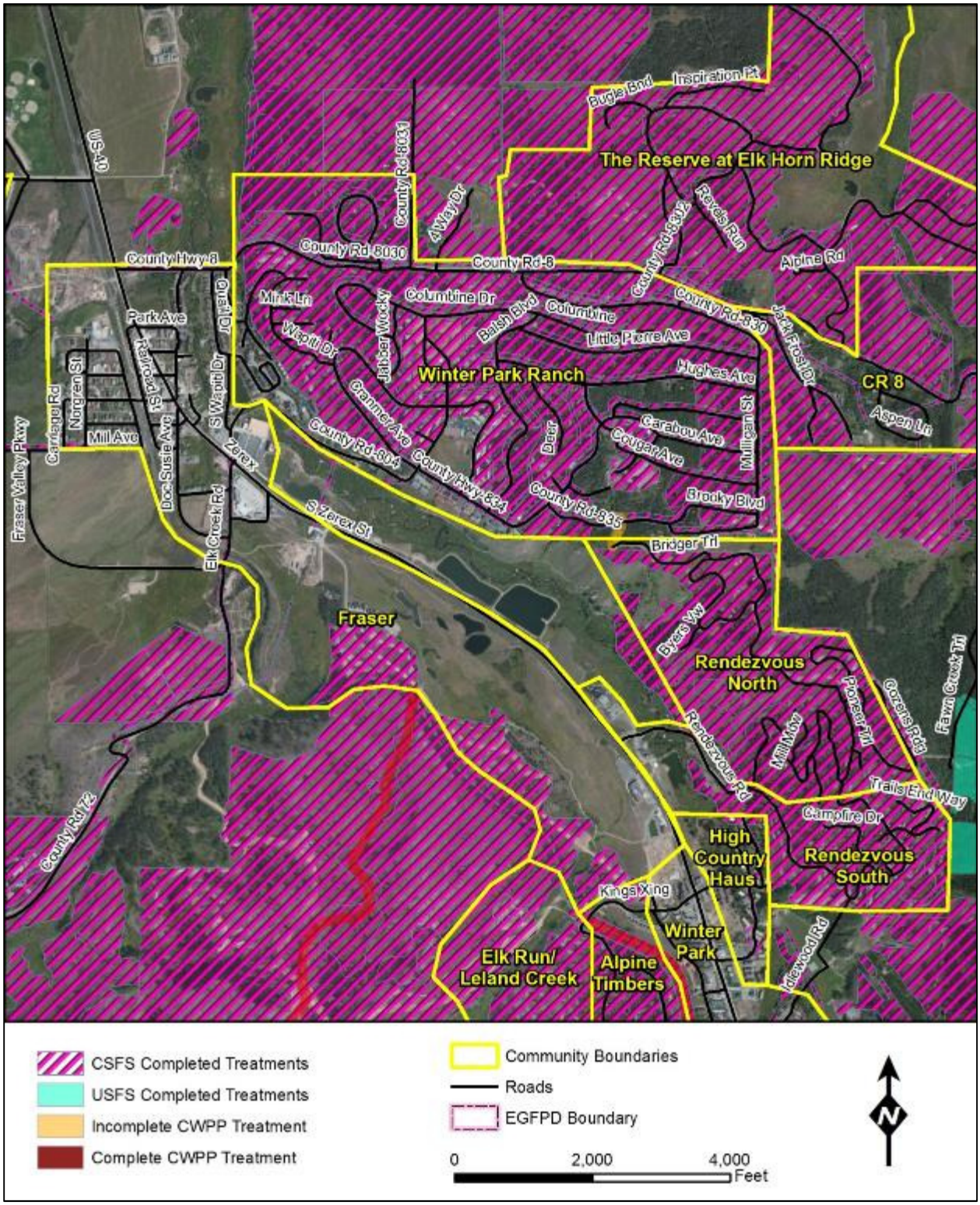

Figure 17. Completed and recommended fuel treatments for Rendezvous South.

17. Sunset Ridge

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	None
Hazards:	Inadequate water supply, ravines, power lines, wooden roofs

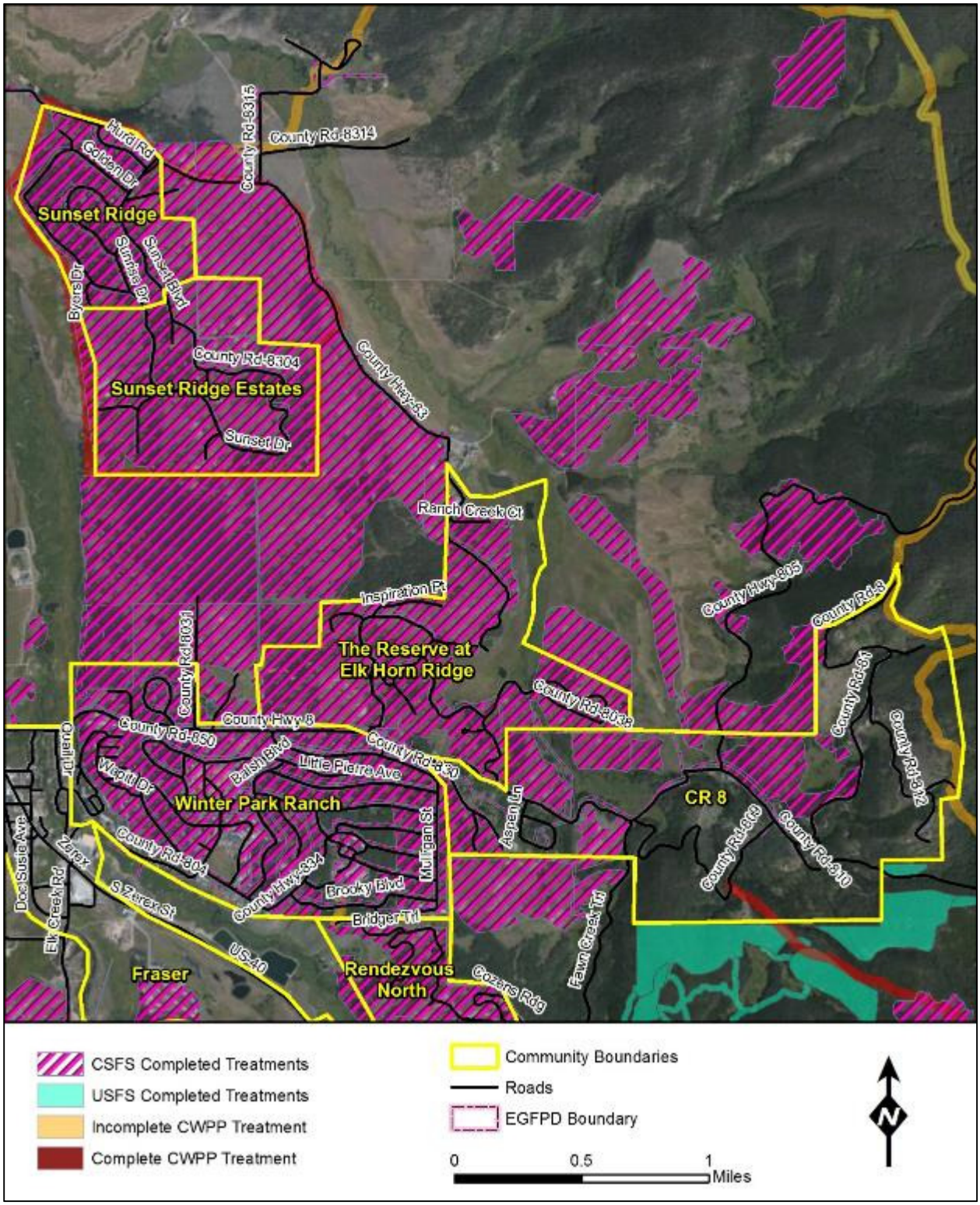

Figure 18. Completed and recommended fuel treatments for Sunset Ridge.

18. The Fairways

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Water supply:	50,000 gal cistern at the golf course maintenance facility, Draft ponds
Hazards:	Ravines

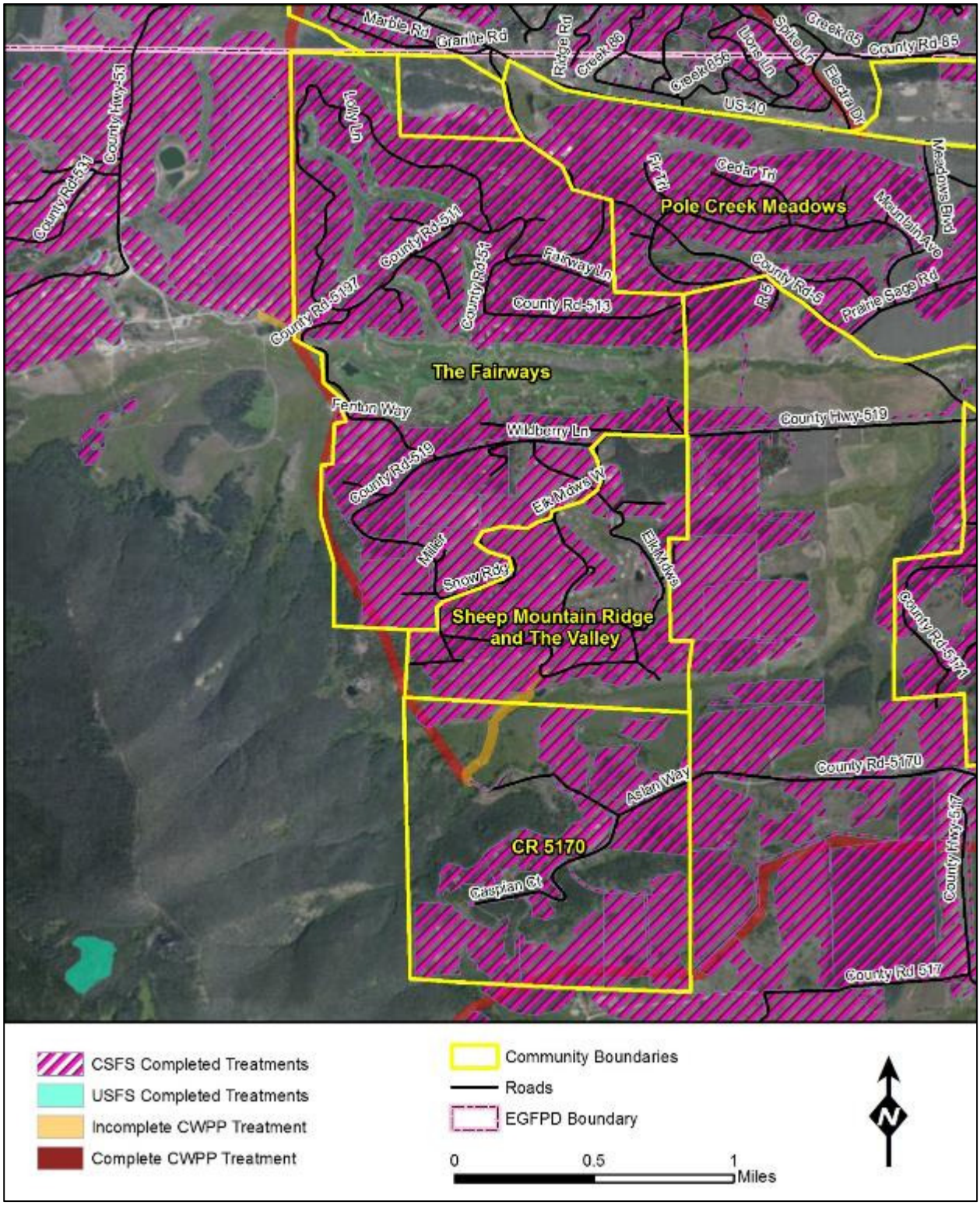

Figure 19. Completed and recommended fuel treatments for the Fairways.

19. Elk Run/Leland Creek

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	Hydrants
Hazards:	Steep slopes, inadequate width roads

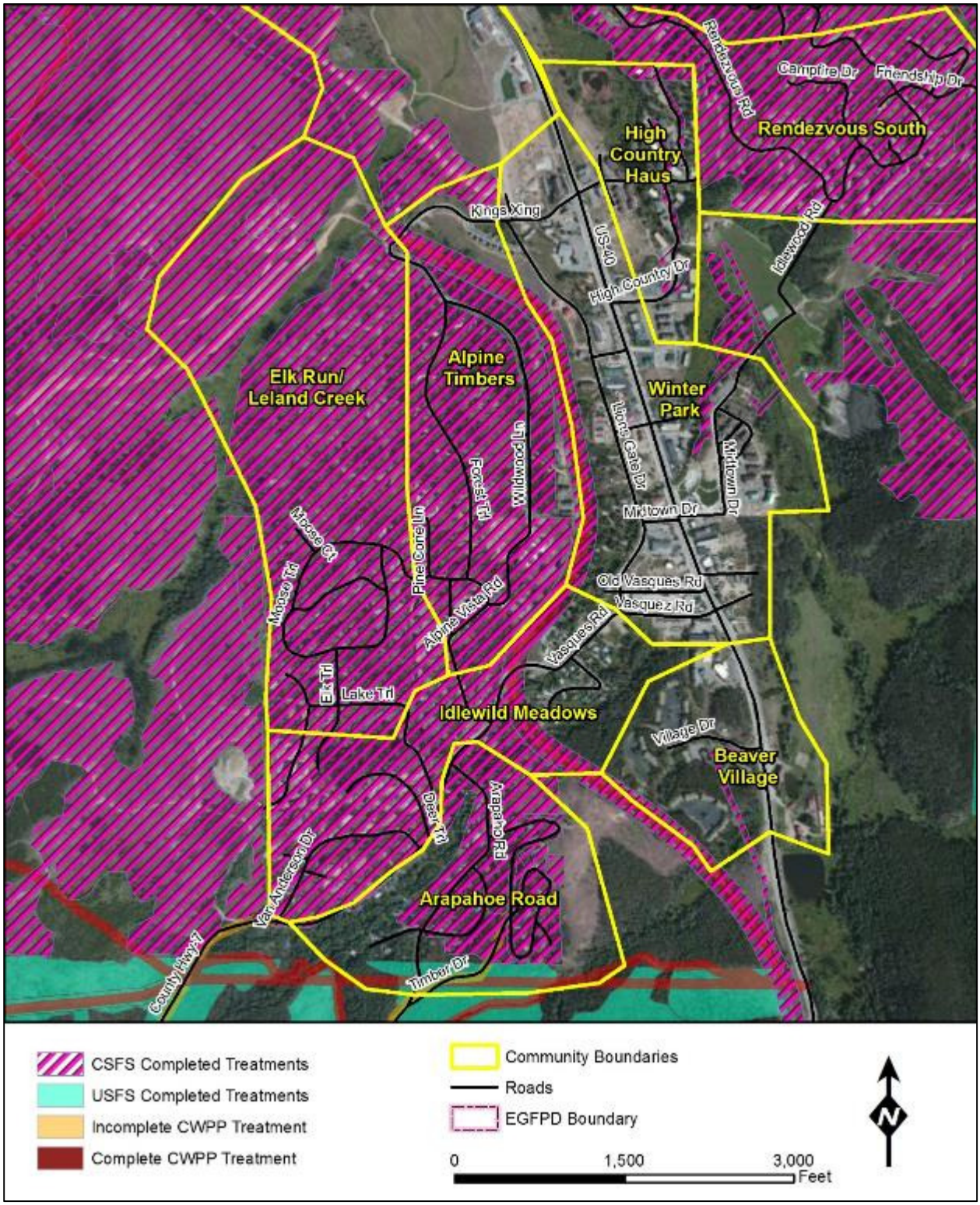

Figure 20. Completed and recommended fuel treatments for Elk Run/Leland Creek.

20. Icebox Estates/Skyview Acres

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Water supply:	None
Hazards:	Inadequate water supply, power lines, wooden roofs

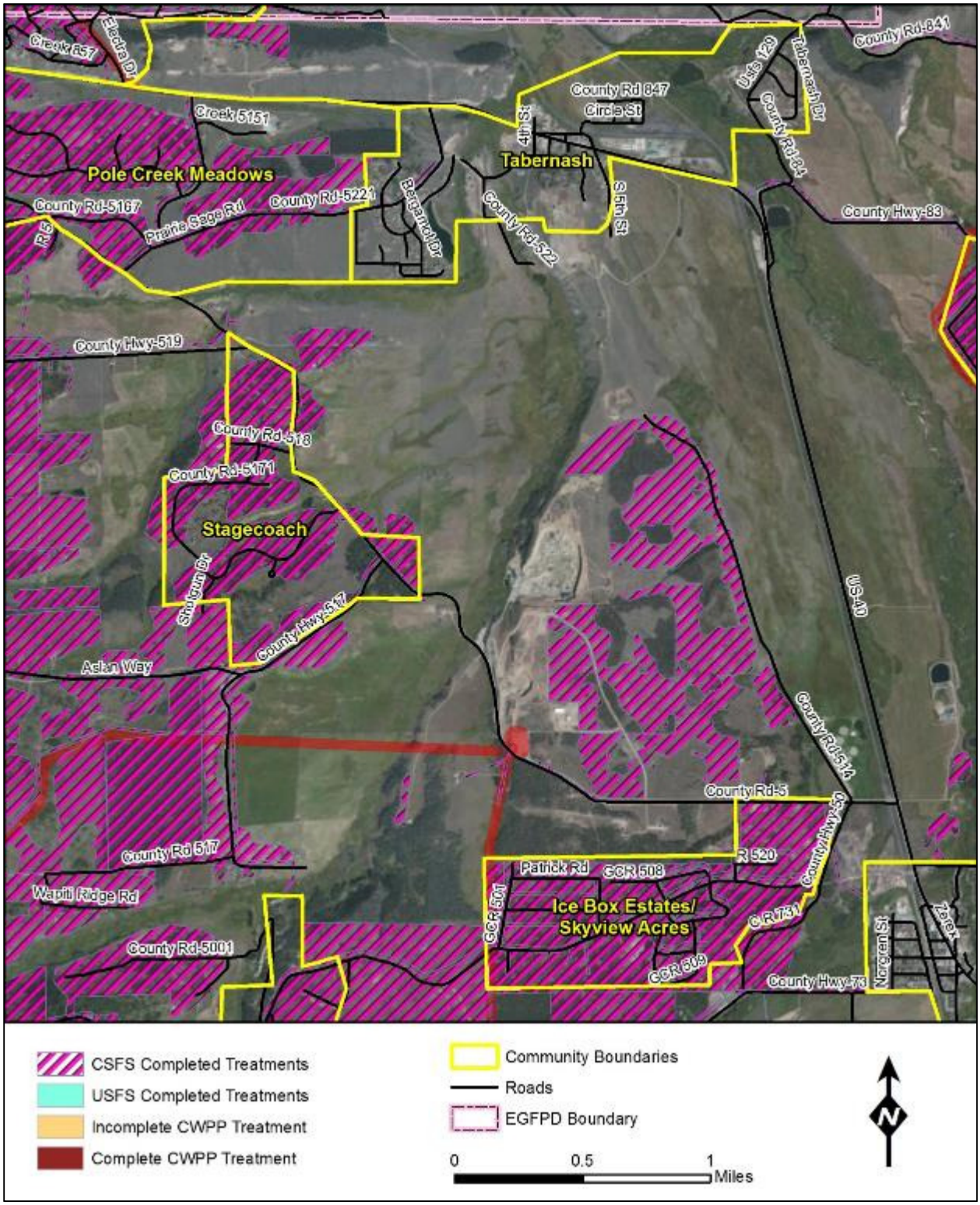

Figure 21. Completed and recommended fuel treatments for Icebox Estates/Skyview Acres.

21. Alpine Timbers

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Inadequate roads, railroad track through heavy fuels

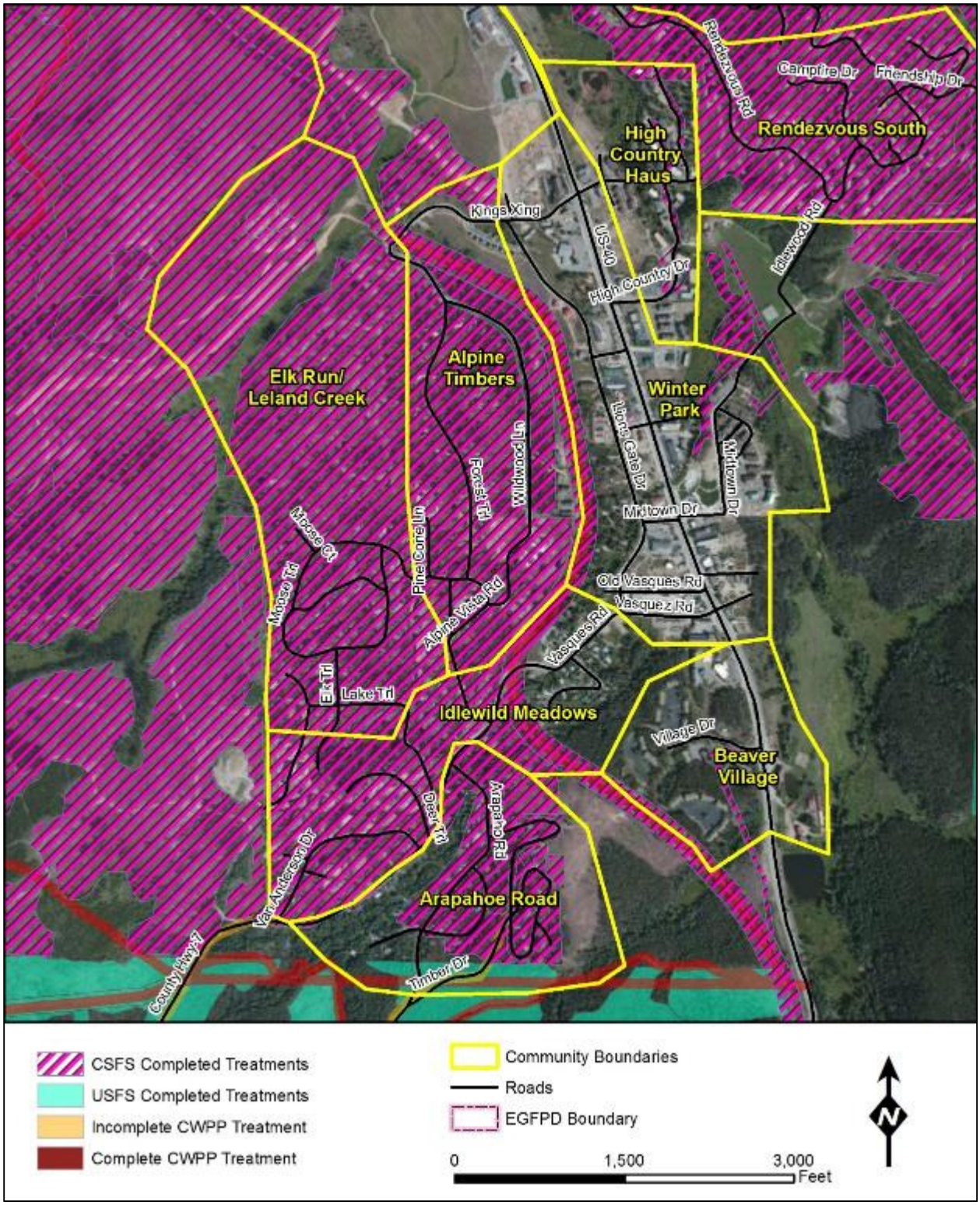

Figure 22. Completed and recommended fuel treatments for Alpine Timbers.

22. Sunset Ridge Estates

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	>5 Acres
Water supply:	One dry hydrant on a pond
Hazards:	Ravines, inadequate water supply, power lines

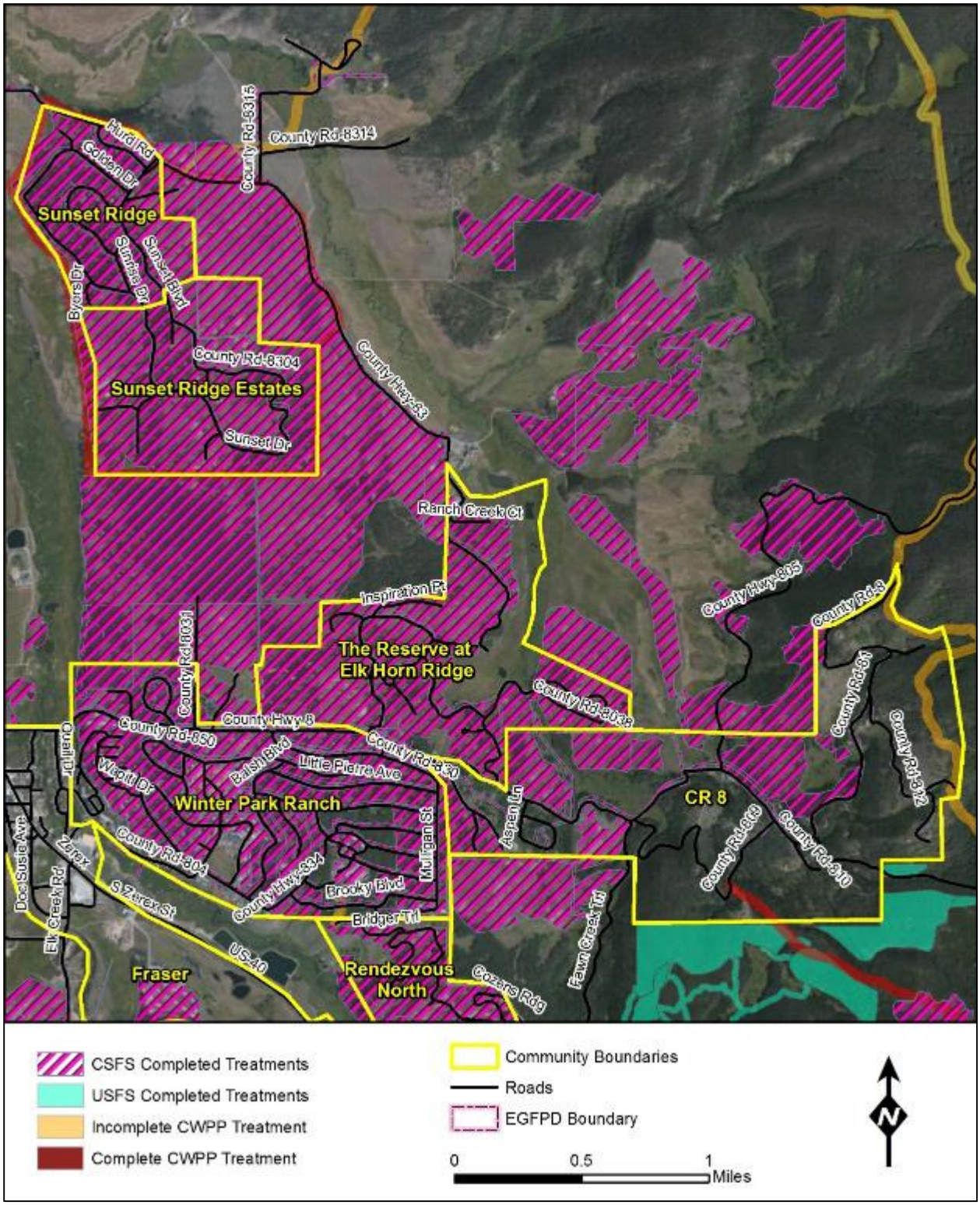

Figure 23. Completed and recommended fuel treatments for Sunset Ridge Estates.

23. Moose Run

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Water supply:	Draft pond
Hazards:	Inadequate water supply

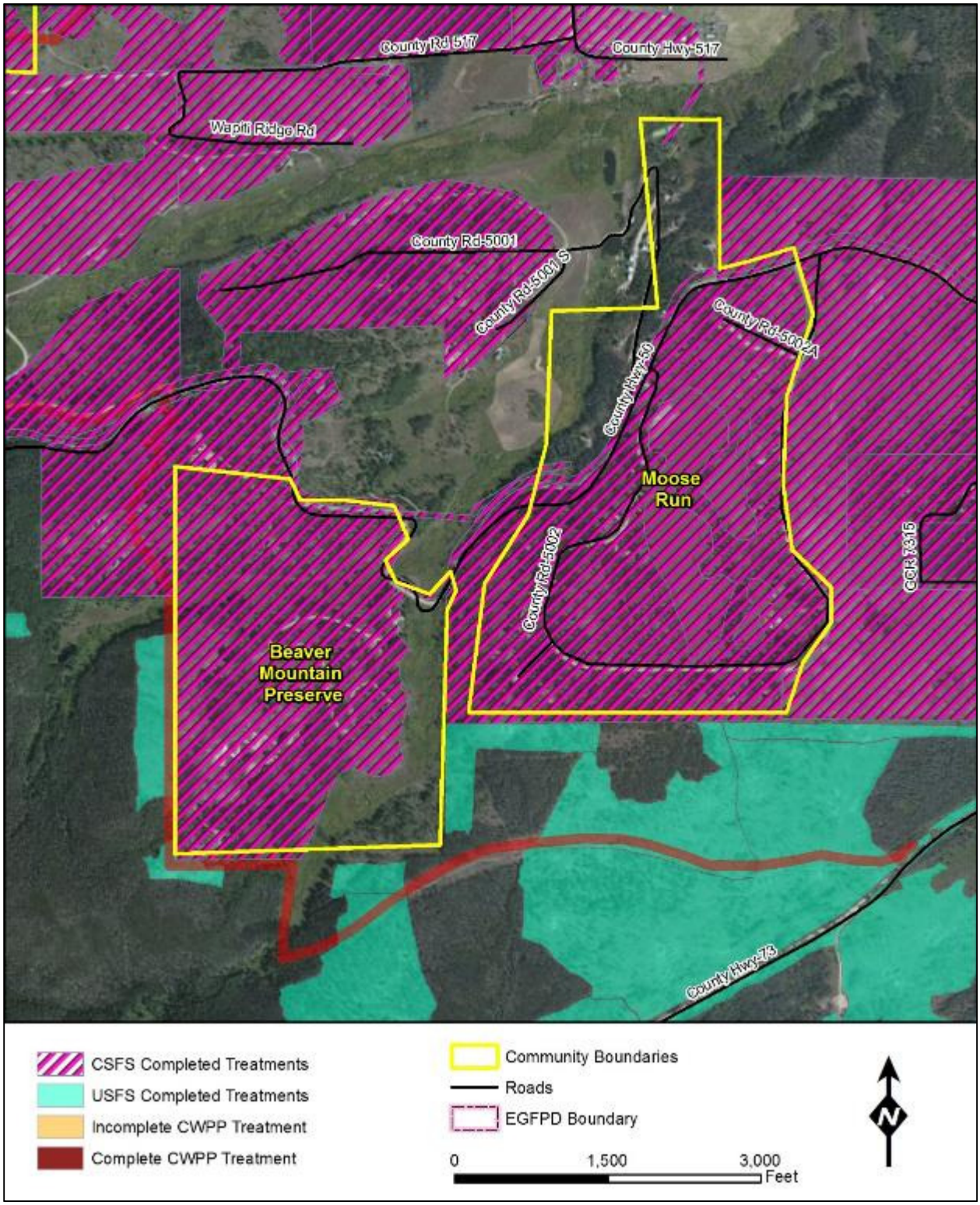

Figure 24. Completed and recommended fuel treatments for Moose Run.

24. High Country Haus

Hazard Rating:	**High**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Inadequate width access roads, power lines

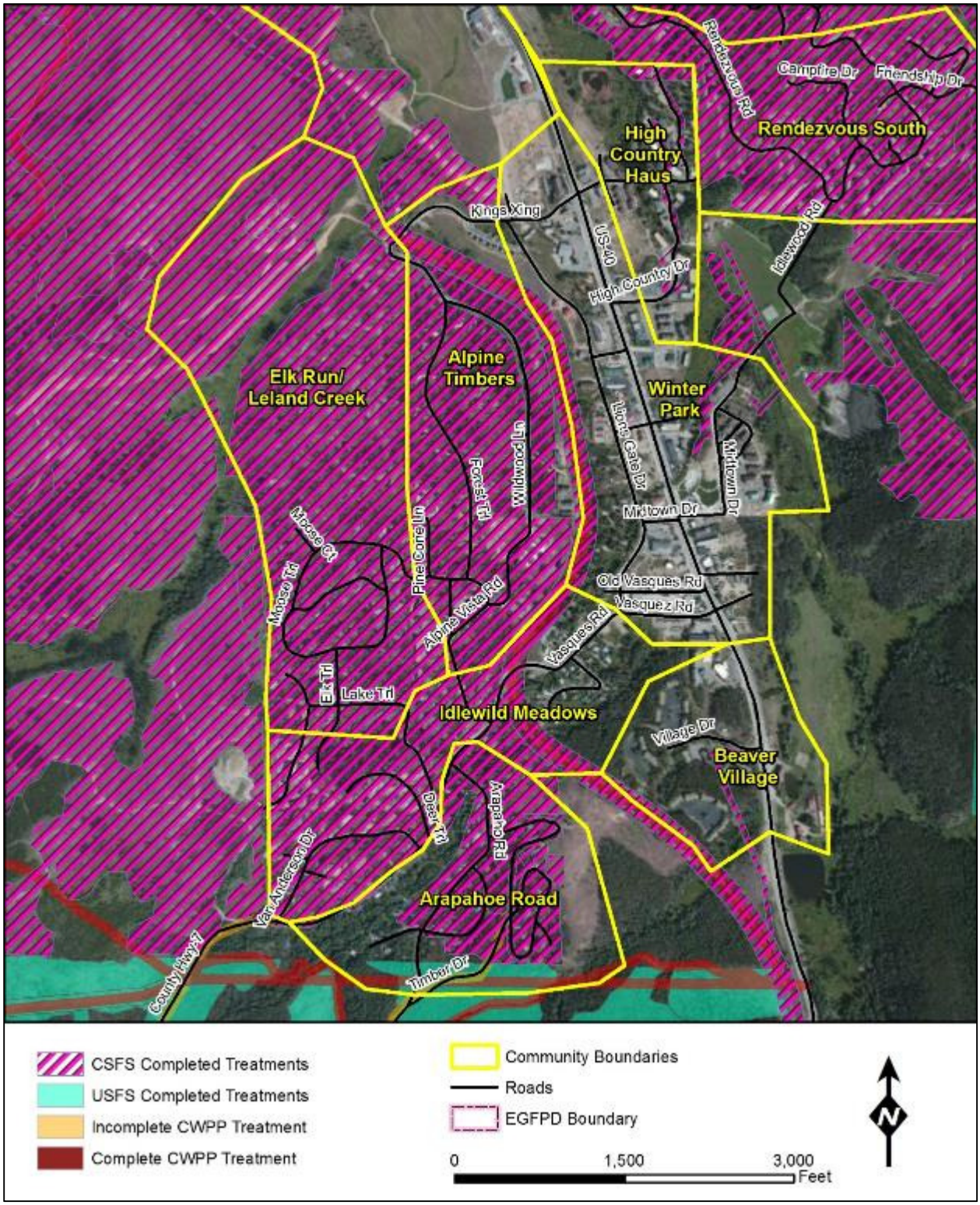

Figure 25. Completed and recommended fuel treatments for High Country Haus.

25. Stagecoach

Hazard Rating:	Moderate
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	No
Average lot size:	1-5 Acres
Water supply:	Pond with a dry hydrant
Hazards:	Inadequate water supply

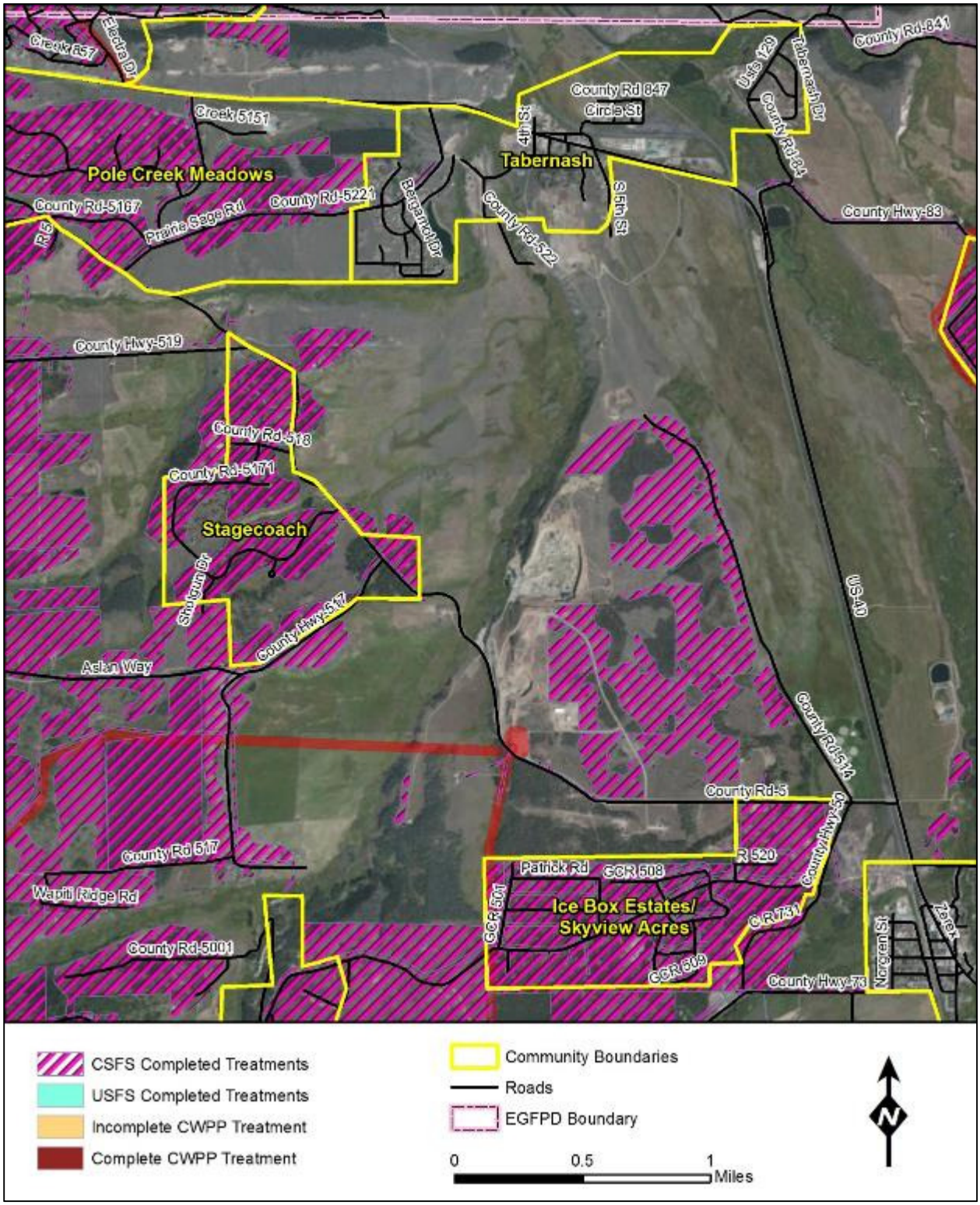

Figure 26. Completed and recommended fuel treatments for Stagecoach.

26. Sheep Mountain Ridge/The Valley

Hazard Rating:	**Moderate**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Water supply:	Hydrants
Hazards:	Ravines, some steep slopes

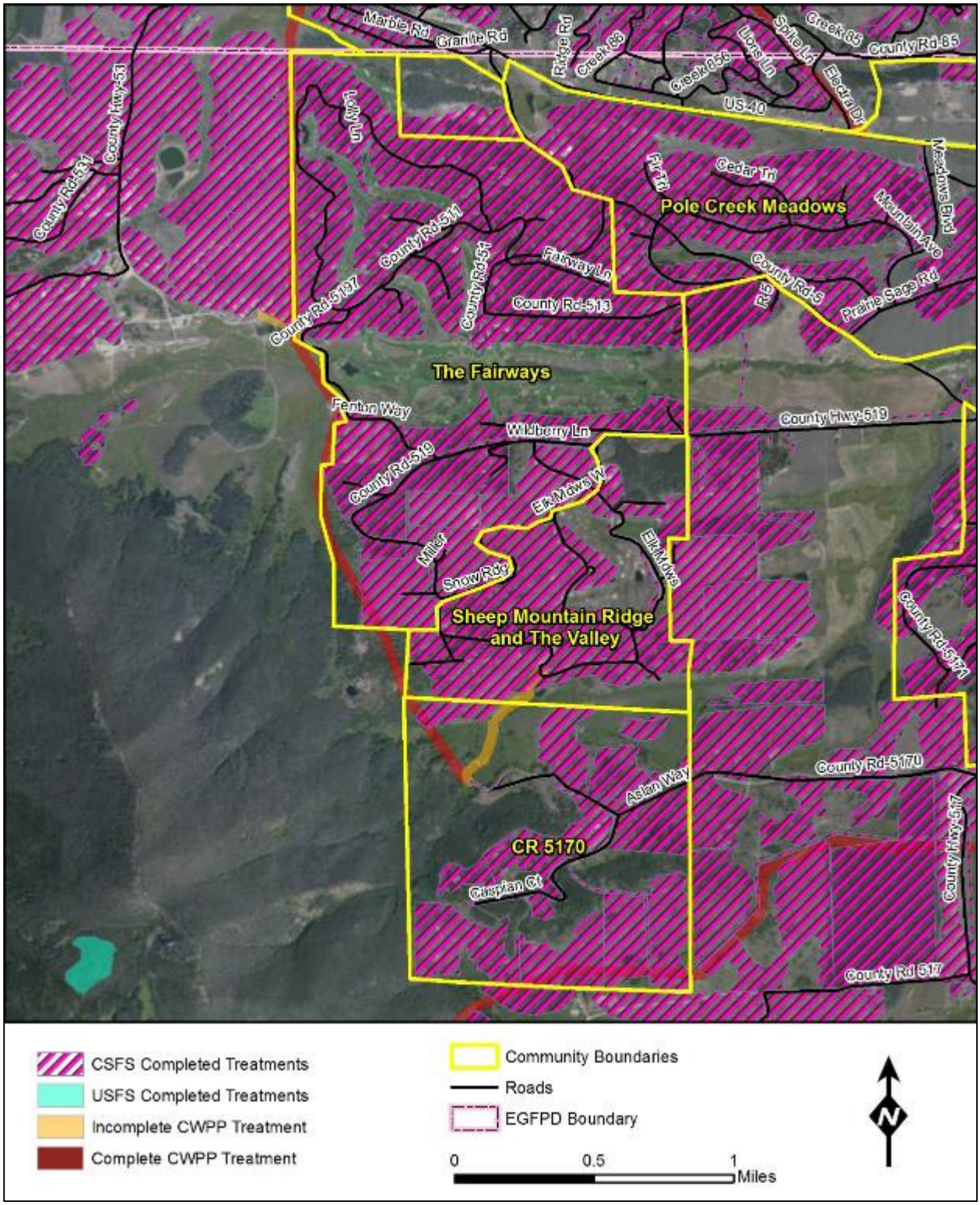

Figure 27. Completed and recommended fuel treatments for Sheep Mountain Ridge/The Valley.

27. Pole Creek Meadows

Hazard Rating:	**Low**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	1-5 Acres
Water supply:	Dry hydrant on a pond
Hazards:	Inadequate water supply, power lines

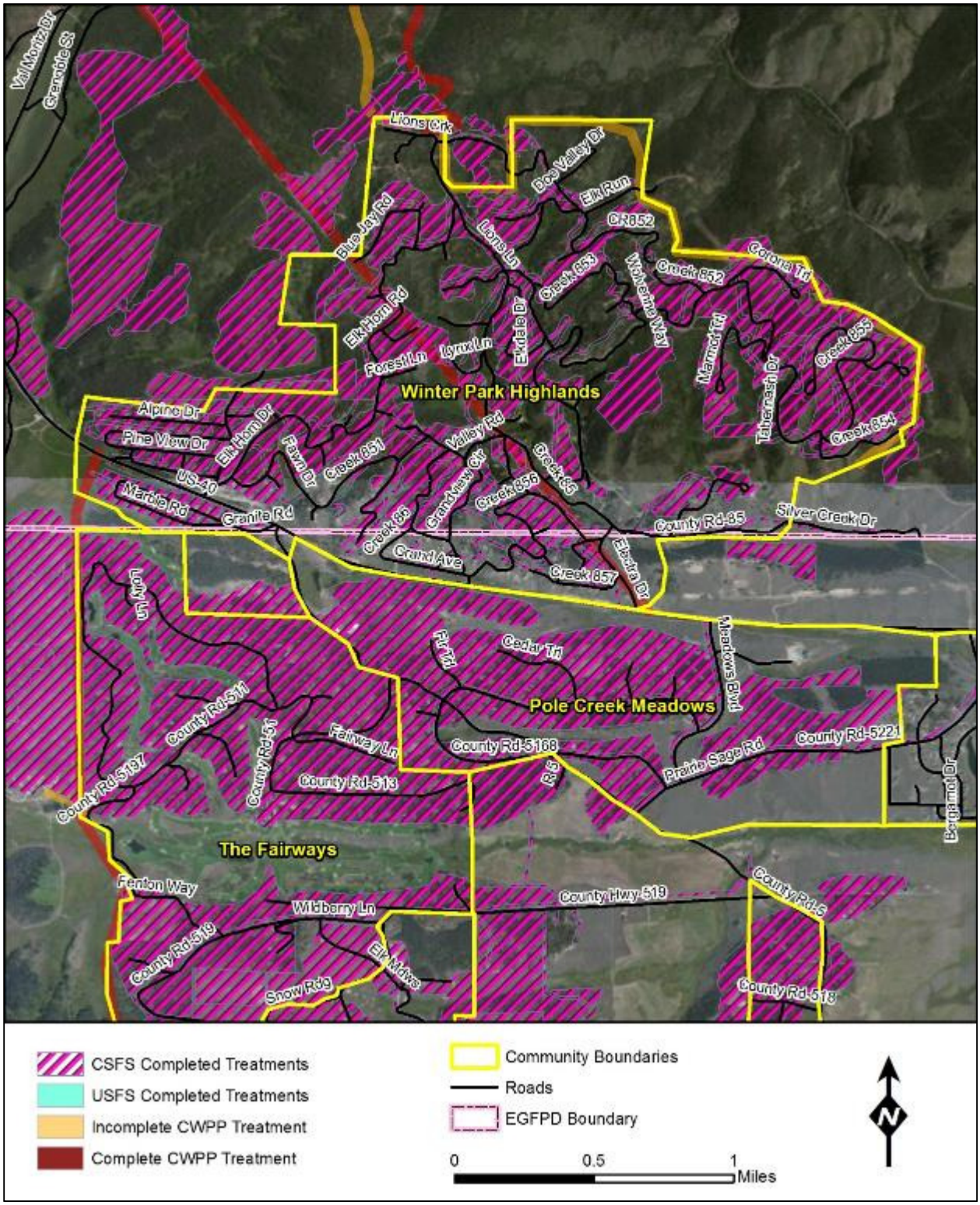

Figure 28. Completed and recommended fuel treatments for Pole Creek Meadows.

28. Winter Park

Hazard Rating:	**Moderate**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Power lines

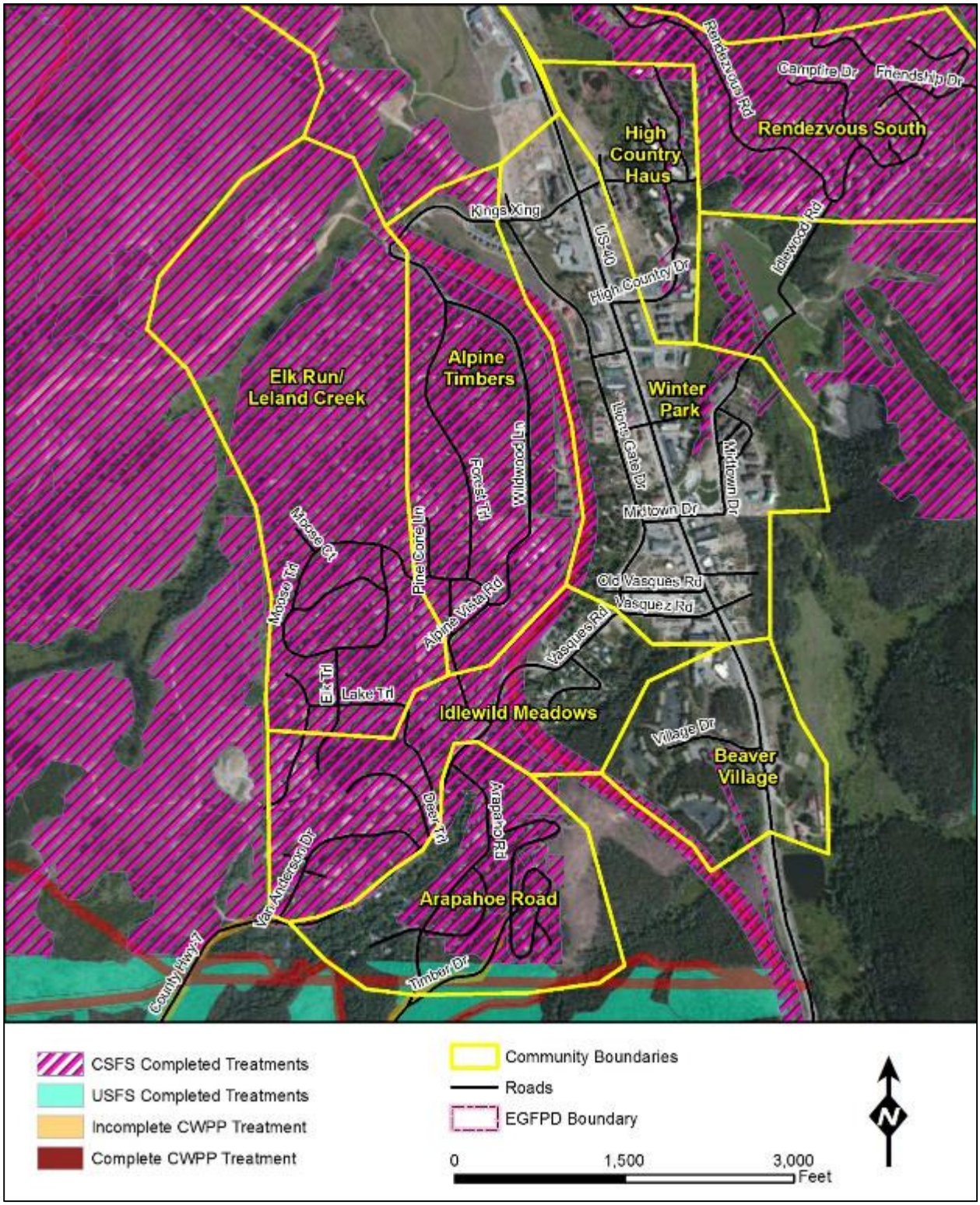

Figure 29. Completed and recommended fuel treatments for Winter Park.

29. Tabernash

Hazard Rating:	**Low**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Wood roofs, power lines

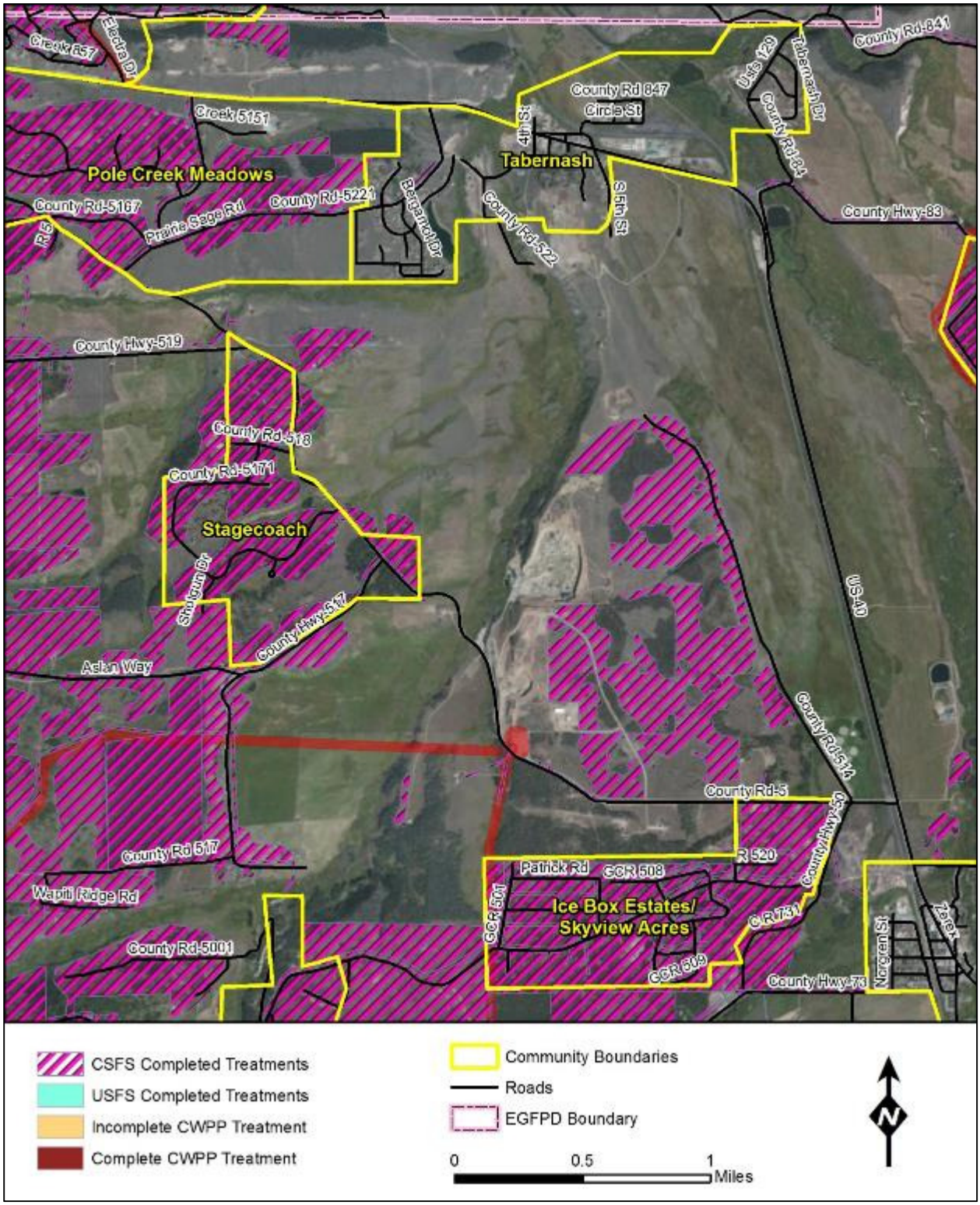

Figure 30. Completed and recommended fuel treatments for Tabernash.

30. Fraser

Hazard Rating:	**Low**
Does the neighborhood have dual access roads?	Yes
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	Hydrants
Hazards:	Wood roofs, power lines

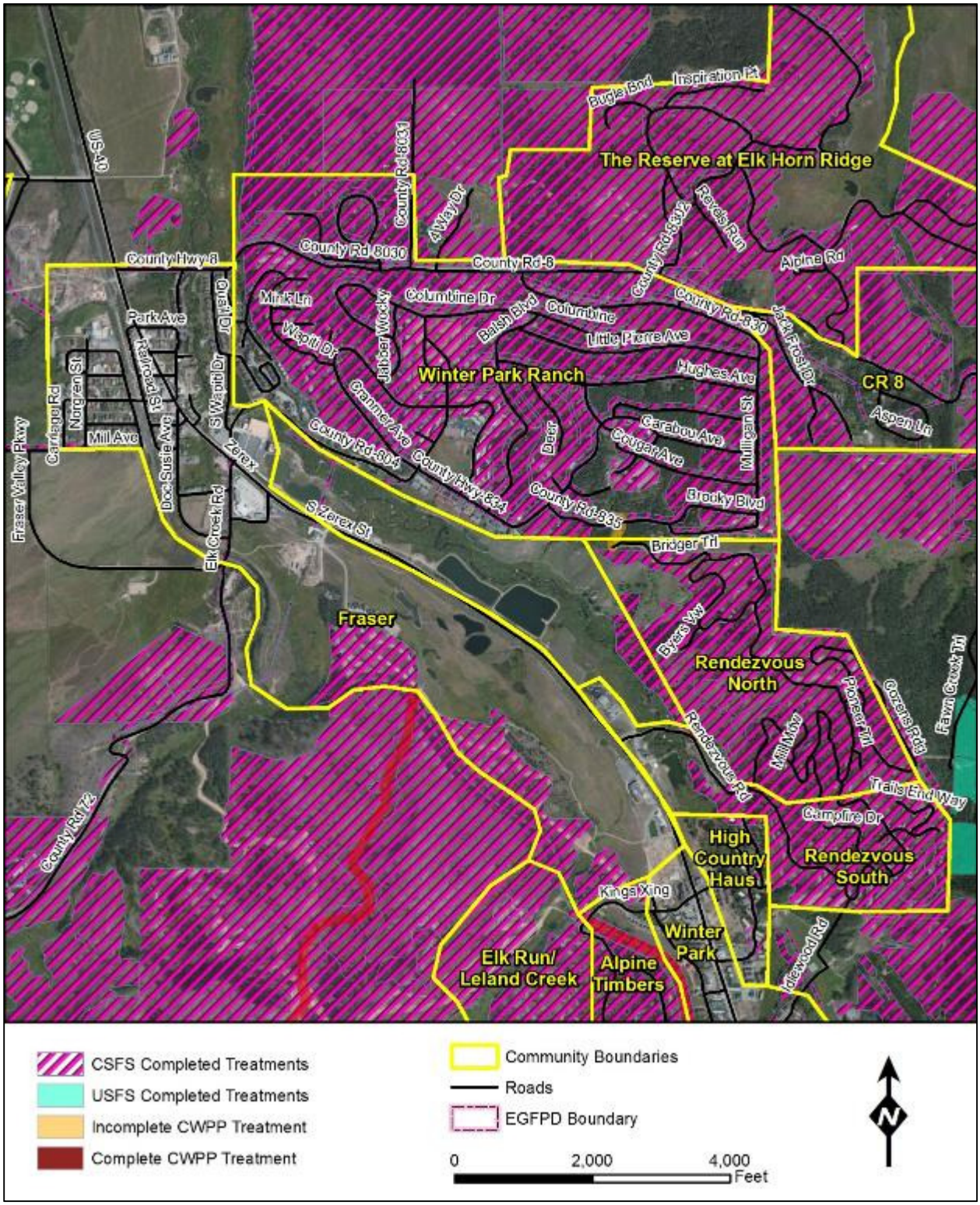

Figure 31. Completed and recommended fuel treatments for Fraser.

31. CR 5170

Hazard Rating:	**Low**
Does the neighborhood have dual access roads?	No
Are there road grades < 8%?	Yes
Are all access roads of adequate width?	Yes
Average lot size:	<1 Acre
Water supply:	One cistern
Hazards:	Inadequate water supply, no duel access

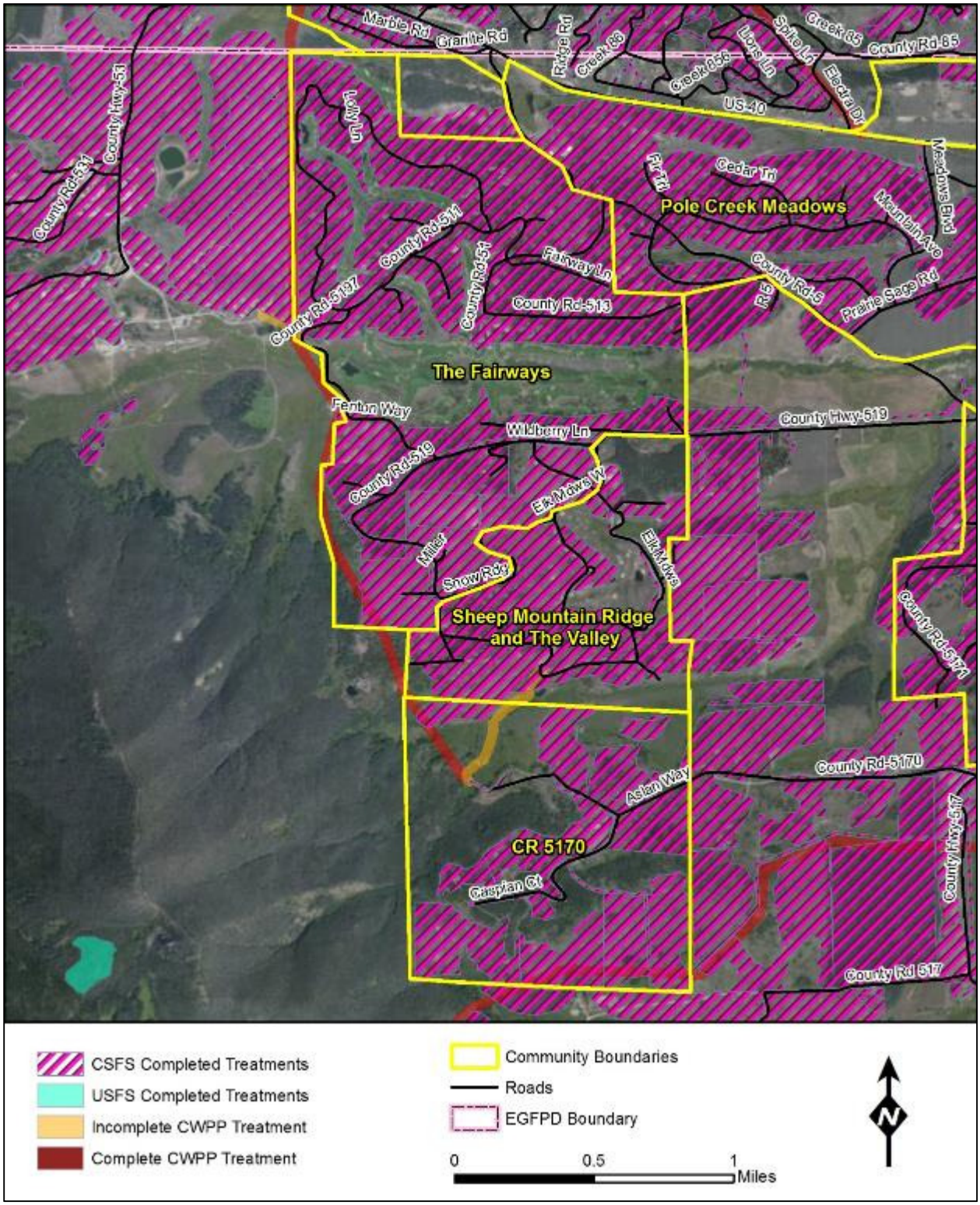

Figure 32. Completed and recommended fuel treatments for CR 5170.

FUEL MITIGATION PROJECTS

Below is the list of all of the projects included in the original CWPP and annual work plan. The page number refers to the page number in this document where the graphic of the treatment can be found. If a project was listed as mostly or partially complete, the graphic shows the fuel reduction as being completed. Projects that were not listed as completed are represented in orange on the maps. Because of the massive amount of work already completed by private landowners, the CSFS, and USFS, there were no additional recommendations for the update.

PROJECT NAME	PAGE NUMBERS	COMPLETED
Aslan Way Escape Route	38, 54, 64	No
Snow Mtn Ranch to Fenton Way	38, 54, 64	No
Winter Park Ranch to Rendezvous	12, 20, 26, 30, 34, 62	No
Power Line Thinning , WP Highlands	6, 56	Yes
YMCA Fuel Break	38, 54, 64	Yes
Distribution Line 1 and 2	42, 52, 60	Yes
Mettler Substation Treatment	12, 20, 26, 30, 34, 42, 52, 60, 62	Mostly
Gas Pipeline Point Treatments	36, 46	Yes
Big Mac/Little Mac Water Treatment Plant Fuel Breaks	14, 22, 32, 40, 44, 50, 58	Partially
Water Treatment Plant Fuel Breaks	14, 22, 32, 40, 44, 50, 58	No
Hurd Creek Water Cisterns	4, 8, 10	No
Unnamed dirt road connecting to WP Highlands to Sol Vista	6, 56	No
Meadow Creek Road Improvements	14, 22, 32, 40, 44, 50, 58	In progress
Hamilton Creek Road Improvements	4, 8, 10	No
Bear Paw Fuel Break	6, 56	No
Tubing Hill Fuel Break	12, 14, 20, 22, 26, 30, 32, 34, 40, 44, 50, 58, 62	Yes
Beaver Mtn Preserve Fuel break	28, 48	90%
Railroad Grade Access Road Improvements	6, 56	Yes
Hamilton Creek Power line Escape Route	4, 8, 10	No
Vasquez Road Fuel Break	14, 22, 32, 40, 44, 50, 58	90%
Winter Park RR Easement Thinning	14, 22, 32, 40, 44, 50, 58	Yes
Transmission line fuel break	38, 54, 64	Mostly
30,000 gal cistern to Sunset Ridge/Sunset Ridge Estates	n/a	No
30,000 gal cistern in Hamilton Creek	n/a	No
Sunset Ridge Fuel break	36, 46	Mostly
30,000 gal cistern in Icebox/Skyview	n/a	No
Denver Water Board Road Improvements	42, 52, 60, 4, 8, 10, 38, 54, 64	Partially
Meadow Creek Fuel break	4, 8, 10	In progress
Meadow Creek Safety Zone	4, 8, 10	No
Hurd Creek Safety Zone	4, 8, 10	No
Two (2) 30,000 gal cisterns to supplement CR 5170	n/a	One

Table 1. List of fuel treatment projects.

WATER SOURCES

In addition to fuel reduction projects, it was recommended that additional water supply be added in several of the communities. For the most part, these projects were not completed, but one cistern was added to CR 5170. The map below shows the most up-to-date map of the water supplies in the FPD, including drafting sites.

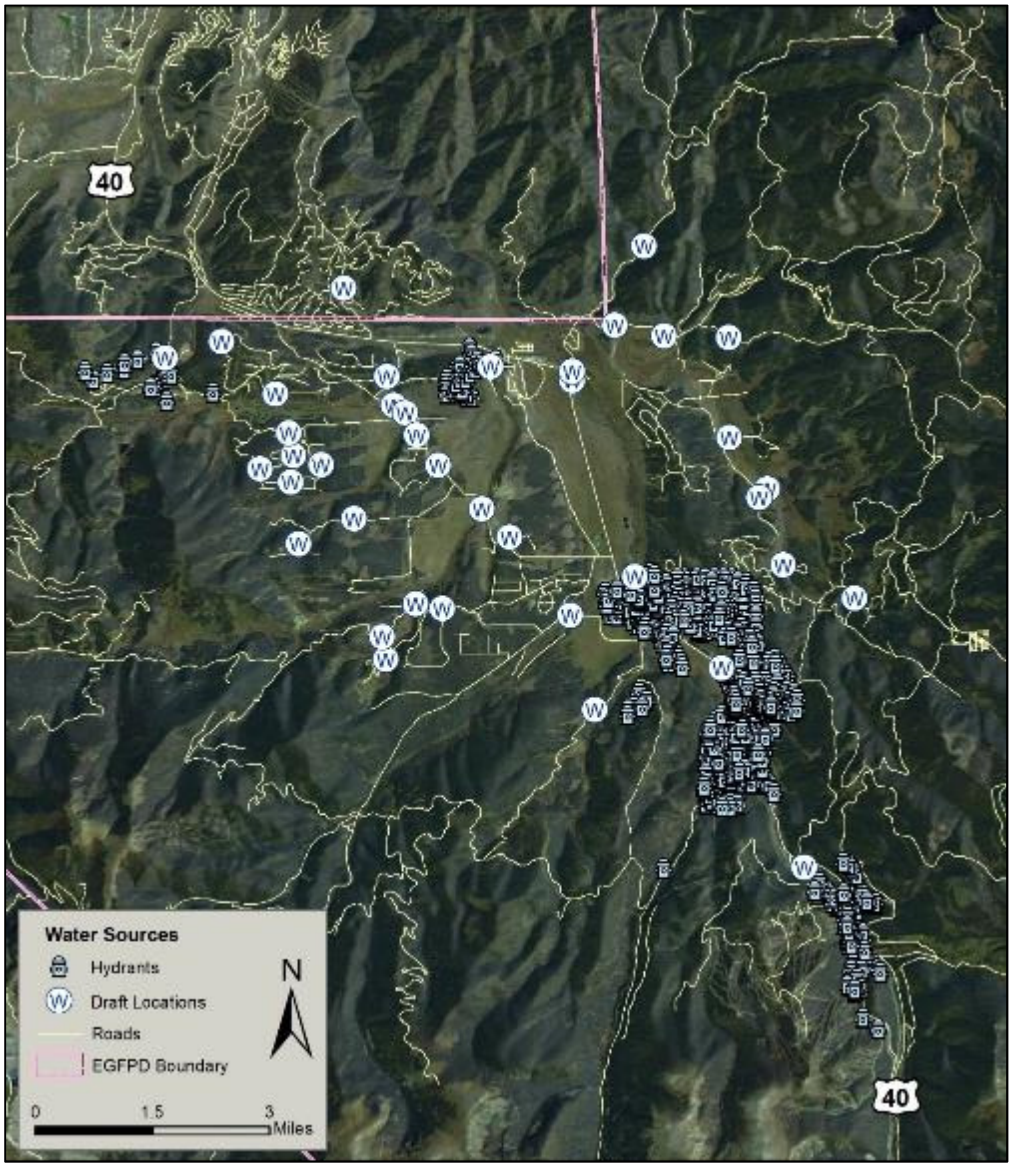

Figure 33. Water supply locations within the East Grand FPD.

FIRE DEPARTMENT CAPABILITIES

Since the completion of the CWPP in 2007, there have been few changes to the fire department capabilities. Several of the apparatus have been updated, but they have the same capacity as their predecessors. In discussions with East Grand Fire and the USFS, there is no reason to update this section at this point in time. Necessary information can be found in the original 2007 document.

FIRE BEHAVIOR TECHNICAL REFERENCE

Fire Behavior Potential Analysis Methodology

Purpose

The purpose of this document is to describe the methodology used to evaluate the threat of fire to the values at risk in the study area. Figure 34 shows a flow chart of the fire behavior modeling process.

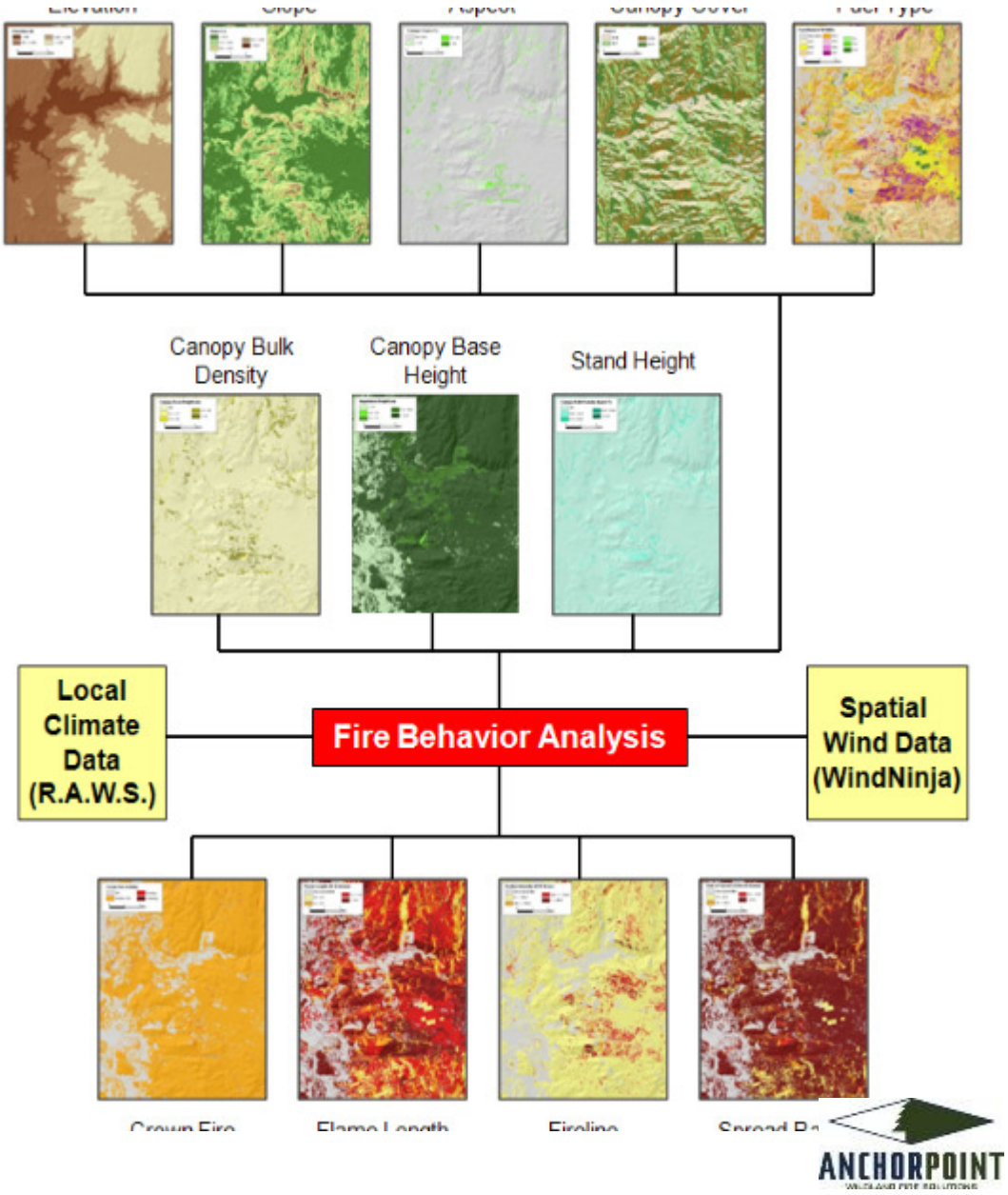

Figure 34. Flow chart showing fire behavior modeling process.

The fire behavior model graphically reports the potential rate of spread, flame length and fireline intensity based on a set of inputs significant to fire behavior. The model inputs include aspect, slope, elevation, canopy cover, fuel type, canopy bulk density, canopy base height, stand height, and climate data. The model outputs are determined using FlamMap, which combines surface fire predictions with the potential for crown-fire development.[1]

Modeling Limitations and Discussion

This evaluation is a prediction of likely fire behavior given a standardized set of conditions and a single point source ignition at every point. It does not consider cumulative impacts of increased fire intensity over time and space. The model does not calculate the probability that a wildfire will occur. It assumes an ignition occurrence for every 30-meter x 30-meter cell. These calculations may be conservative (under-predict) compared to observed fire behavior.

Weather conditions are extremely variable and all possible combinations cannot be accounted for. These outputs are best used for preplanning and not as a stand-alone product for tactical planning. Whenever possible, fire behavior calculations should be done with actual weather observations during the fire. The most current fire danger indices should also be distributed during the fire season to be used as a guideline for fire behavior potential.

Anchor Point's fire behavior modeling process for surface fire draws heavily from the BEHAVE fire behavior prediction and fuel modeling system.[2] BEHAVE is a nationally recognized software program in the United States. It is used to calculate a surface fire's intensity and rate of spread given certain topographical features, fuels, and weather conditions.

The BEHAVE modeling system has been used for a variety of applications, including predictions of current fires, prescribed fire planning, fuel hazard assessment, initial attack dispatch and fire-prevention planning and training. Predictions of wildland surface fire behavior are made for a single point in time and space, given user-defined fuels, weather, and topography. Requested values depend on the modeling choices made by the user.

Assumptions of BEHAVE:

- Fire is predicted at the flaming front. (Fire behavior is not modeled for the time after the flaming front of the fire has passed.)
- Fire is free burning (uncontrolled by suppression efforts).
- Behavior is heavily weighted toward the fine fuels (grasses and small-diameter wood).
- Fuels are continuous and uniform.
- Fires are considered to be surface fires. (Crown fire activity is modeled separately.)

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[1] Mark Finney, Stuart Brittain, and Rob Seli. The Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana), the Bureau of Land Management and Systems for Environmental Management (Missoula, Montana).

[2] Patricia L. Andrews, producer and designer, Collin D. Bevins, programmer and designer, The Joint Fire Sciences Program of the Rocky Mountain Research Station (USDA Forest Service, Missoula, Montana) and Systems for Environmental Management (Missoula, Montana).

BEHAVE makes calculations at a single point. In order to make calculations for an entire landscape (important for preplanning the effects of a wildfire at the community, district, or county scale), fire behavior is modeled using FlamMap, which models surface-fire predictions and the potential for crown-fire development.[3]

Assumptions of FlamMap:

- Each calculation in a given area is independent of calculations in any other area. Fire is not modeled dynamically across the landscape but statically as a series of individual calculations.
- Weather inputs such as wind and fuel moistures do not change over time.
- Fire behavior modeling calculations are performed in a series of uniform squares (or "pixels") across the landscape. These pixels determine the level of detail and nothing smaller than a pixel (30 meters x 30 meters in this case) is included in the modeling.

Rate of spread, flame length and crown fire activity are derived from the fire behavior predictions. A limitation of FlamMap is that crown fire is not calculated for shrub models. The best method for determining the probability of crown fire in shrubs is to look at the flame length outputs and assume that if the flame length is greater than half the height of the plant, it will likely torch and/or crown. The following maps graphically display the outputs of FlamMap for moderate and extreme fire weather conditions.

The fire behavior prediction maps are best used for preplanning and not as a stand-alone product for tactical planning. If this information is used for tactical planning, fire behavior calculations should be done with actual weather observations during the fire event. For greatest accuracy, the most current Energy Release Component (ERC) values should be calculated and distributed during the fire season to be used as a guideline for fire behavior potential.

FlamMap

Anchor Point used FlamMap to evaluate the potential fire conditions in the fire behavior study area. The study area is broken down into grid cells 30 meters x 30 meters, for each of which fire behavior is predicted based on input fuel, weather and topographic information.

[3] Van Wagner, C.E. 1977. "Conditions for the start and spread of a crown fire." *Canadian Journal of Forest Research*. 7: 23-24.

Reference Weather and Fuel Moisture Used in the Fire Behavior Potential Evaluation

Fine dead fuels, such as small twigs and grass, lose moisture rapidly and have the greatest day-to-day variation. Fuel moisture will increase during periods of rain or snow and high humidity. Sunlight will lower the relative humidity and increase the temperature resulting in the fuel losing moisture. The longer fuel is exposed to dryer conditions, the dryer it will get. Grass has the potential to ignite and support fire spread throughout the year, even in winter months. High winds can quickly lower fuel moistures and help dry fuels. It will blow away the moisture-laden air next to the fuel and replace it with drier air. This will increase the rate of spread and the flame lengths. Because fine fuels respond so quickly and can burn year-round, using both moderate and extreme fire weather scenarios can better help determine the actions needed to best protect infrastructure and the landscape itself.

Weather data were analyzed to capture a moderate and extreme fire weather day (in terms of fuel moistures and wind speed). These variables were used to determine 1-hour, 10-hour, and 100-hour fuel moistures and 20-foot wind speeds. The NOAA wind speed conversion chart was used to convert to the probable max one minute speed, which was 10 mph for the moderate weather scenario and 22 mph for extreme. The following values were used as climate/fuel moisture inputs in FlamMap:

Moderate Fire Weather Conditions	
Variable	**Value**
20-foot wind speed upslope	10*
Herbaceous fuel moisture	89%
Woody fuel moisture	119%
1-hr fuel moisture	6%
10-hr fuel moisture	8%
100-hr fuel moisture	14%

Extreme Fire Weather Conditions	
Variable	**Value**
20-foot wind speed upslope	22*
Herbaceous fuel moisture	30%
Woody fuel moisture	79%
1-hr fuel moisture	4%
10-hr fuel moisture	6%
100-hr fuel moisture	12%

Table 2. Input wind and fuel moisture parameters used for fire behavior models.

* Winds blowing uphill.

Upslope Winds
Upslope winds were used instead of directional winds because aligning slope and wind will give the worst case scenario results. Directional winds would favor one aspect over another and would show lower fire behavior on the leeward aspects. This is only the case under the given wind direction and would not account for other possible wind directions.

Dead Fuel Moisture
Dead fuel moisture responds solely to ambient environmental conditions and is critical in determining fire potential. Dead fuel moistures are classed by timelag. A fuel's timelag is proportional to its diameter and is loosely defined as the time it takes a fuel particle to reach two-thirds equilibrium with its local environment. Dead fuels in the National Fire Danger Rating System (NFDRS) fall into four classes: 1-hour, 10-hour, 100-hour, and 1,000-hour.[4]

Live Fuel Moisture
Live fuel moisture is the amount of water in a fuel, expressed as a percent of the oven-dry weight of that fuel. Fuel moisture between 300 percent and 30 percent is considered live. Anything below 30 percent is considered dead fuel. Fuel moistures can exceed 100 percent because the living cells can expand beyond their normal size to hold more water when available.

Fuel Models and Fire Behavior
In the context of fire behavior modeling, "fuel models" are a set of numbers that describe fuels in terms that the fire behavior modeling equations can use directly. There are seven characteristics used to categorize fuel models:

- Fuel loading
- Size and shape
- Compactness
- Horizontal continuity
- Vertical arrangement
- Moisture content
- Chemical content

Each of the major fuel types present in the study area is described below. Unless otherwise noted, fuel model descriptions are taken from Scott and Burgan's *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model*, a national standard guide to fuel modeling.[5]

[4] U.S. National Fire Danger Rating System Overview: INT-GTR-367 - FIRES: Fire Information Retrieval and Evaluation System - a Program for Fire Danger Rating Analysis.
[5] Scott, J.H. and R. Burgan. 2005. *Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model*, United States Department of Agriculture Forest Service, RMRS-GTR-153.

In *Standard Fire Behavior Fuel Models*, Scott and Burgan describe 40 fuel models in the following six groups: non-burnable (NB), grass (GR), grass/shrub (GS), shrub (SH), timber understory (TU) and timber litter (TL).

Fuel Models

Grass Fuel Models	Grass-Shrub Fuel Models	Shrub Fuel Models	Timber Understory Fuel Models	Timber Litter Fuel Models	Non-Burnable
FM101 (GR1)	FM121 (GS1)	FM141 (SH1)	FM161 (TU1)	FM181 (TL1)	NB1 (91) Urban/Developed
FM102 (GR2)	FM122 (GS2)	FM147 (SH7)	FM164 (TU4)	FM183 (TL3)	NB2 (92) Snow/Ice
			FM165 (TL5)	FM188 (TL8)	NB3 (93) Agricultural
					NB8 (98) Open Water
					NB9 (99) Bare Ground

Table 3. Fuel models found in the East Grand FPD.

Any vegetation that can burn is considered a fuel. The most common fuel models in the study area are TU4 (Dwarf Conifer with Understory (adapted to reflect post-beetle conditions) and SH1 (Low Load Dry Climate Shrub).

Grass Fuel Models

The primary carrier of fire in the GR fuel models is grass. Fire behavior varies from moderate rate of spread and low flame length in the sparse grass to extreme rate of spread and flame length in the tall grass models.

All GR fuel models are dynamic, meaning that their live herbaceous fuel load shifts from live to dead as a function of live herbaceous moisture content. The effect of live herbaceous moisture content on spread rate and intensity is strong.

Grass-Shrub (GS) Fuel Models
The primary carrier of fire in the GS fuel models is grass and shrubs combined; both components are important in determining fire behavior.

All GS fuel models are dynamic, meaning that their live herbaceous fuel load shifts from live to dead as a function of live herbaceous moisture content. The effect of live herbaceous moisture content on spread rate and intensity is strong and depends on the relative amount of grass and shrub load in the fuel model.

Timber-Understory (TU) Fuel Models

The primary carrier of fire in the TU fuel models is forest litter in combination with herbaceous or shrub fuels. TU3 contains live herbaceous load and is dynamic, meaning that its live herbaceous fuel load is allocated between live and dead as a function of live herbaceous moisture content. The effect of live herbaceous moisture content on spread rate and intensity is strong and depends on the relative amount of grass and shrub load in the fuel model.

Timber-Litter (TL) Fuel Models
The primary carrier of fire in the TL fuel models is dead and down woody fuel. Live fuel, if present, has little effect on fire behavior.

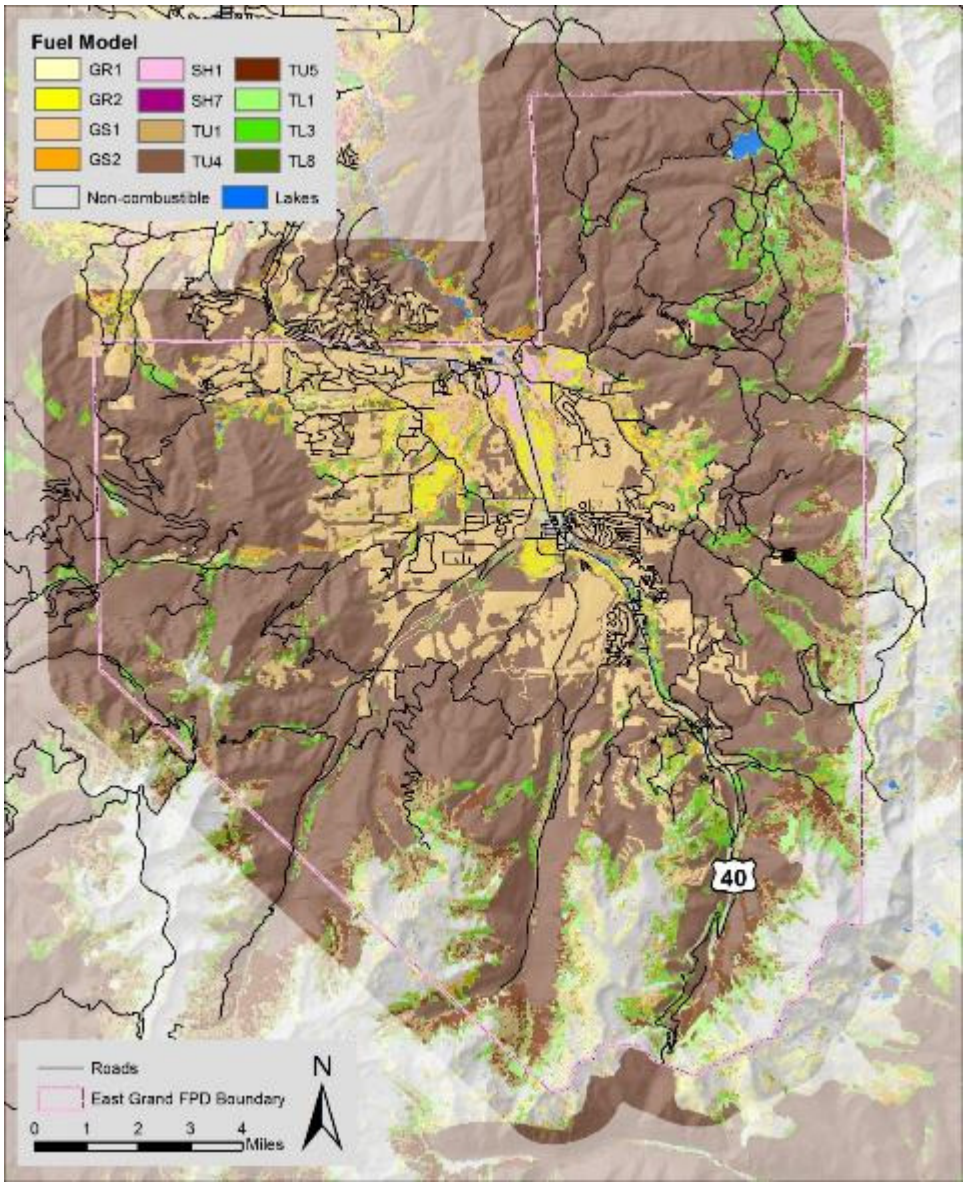

Figure 35. Map of the various fuel models found in the study area.

To reflect the changes wrought by the mountain pine beetle in the area, aerial survey data were used to adjust the input layers for fire behavior modeling. Any area identified as having had mountain pine beetle activity was set to fuel model TU4 (Dwarf Conifer with Understory). While the description of the layer is not necessarily accurate, the fuel model parameters produce more accurate fire behavior output results. In these areas, canopy bulk densities were doubled and canopy base heights were multiplied by 0.75. These adjustments have all been used with success on previous active fires.

In addition, to account for the acres killed by the MPB, the massive number of acres treated by the CSFS and USFS needed to be addressed. To do so, fuel model SH1 (Low Load Dry Climate Shrub) was used when running the models. This fuel model is a more accurate representation

of the areas that have experienced clear-cutting and other mitigation activities over the last 6 years.

Fire Behavior Outputs

Rate of Spread

Spread rate values are generated by FlamMap and are classified into six categories in chains/hour.

Note: A high rate of spread is not necessarily severe. Fire will move very quickly across grass fields but will not burn very hot and does not cause any major damage to the soil.

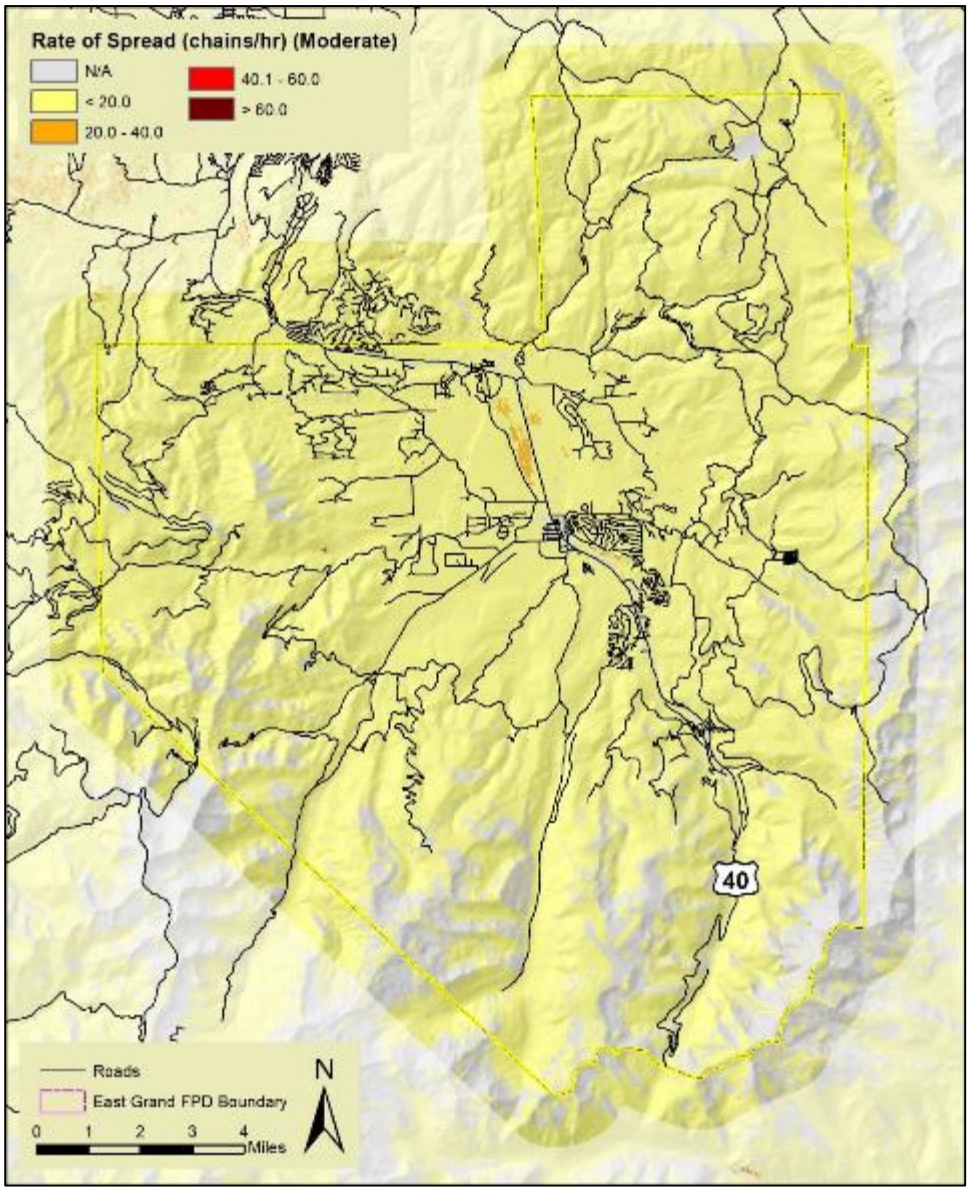

Figure 36. Predicted rate of spread under moderate weather conditions.

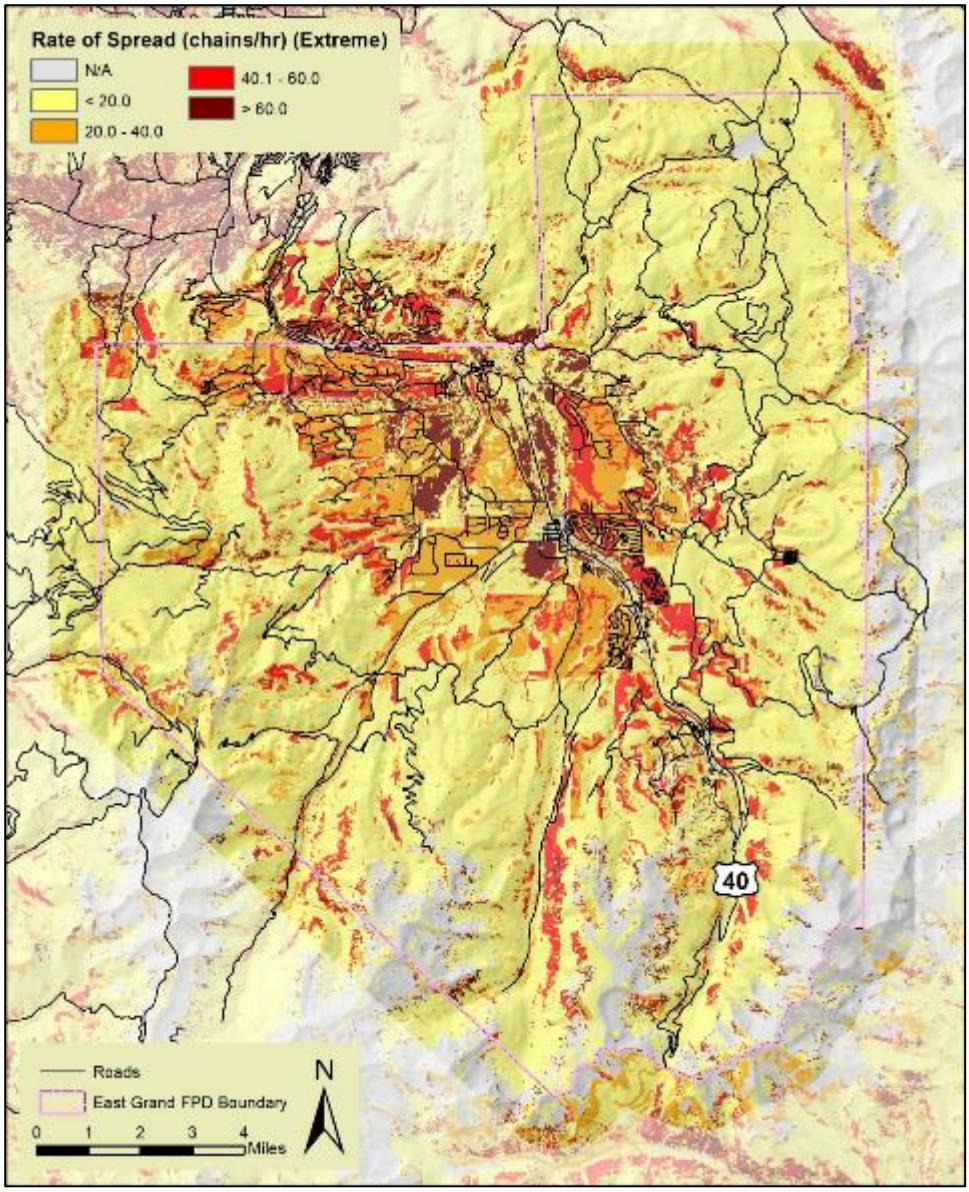

Figure 37. Predicted rate of spread under extreme weather conditions.

Flame Length

Flame length values are generated by the FlamMap model and classified into four categories in feet.

The flame lengths are a direct measure of how intense the fire is burning. Flame lengths of 4 feet and less are deemed to be low enough intensity to be suitable for direct attack by hand crews and therefore represent the best chances of direct extinguishment and control. Flame lengths of less than 8 feet are suitable for direct attack by equipment such as bulldozers and tractor plows. Flame lengths of greater than 8 feet are usually attacked by indirect methods and aircraft. In conditions where flame lengths exceed 11 feet, the most effective tactics are fuel consumption ahead of the fire by burnouts or mechanical methods.

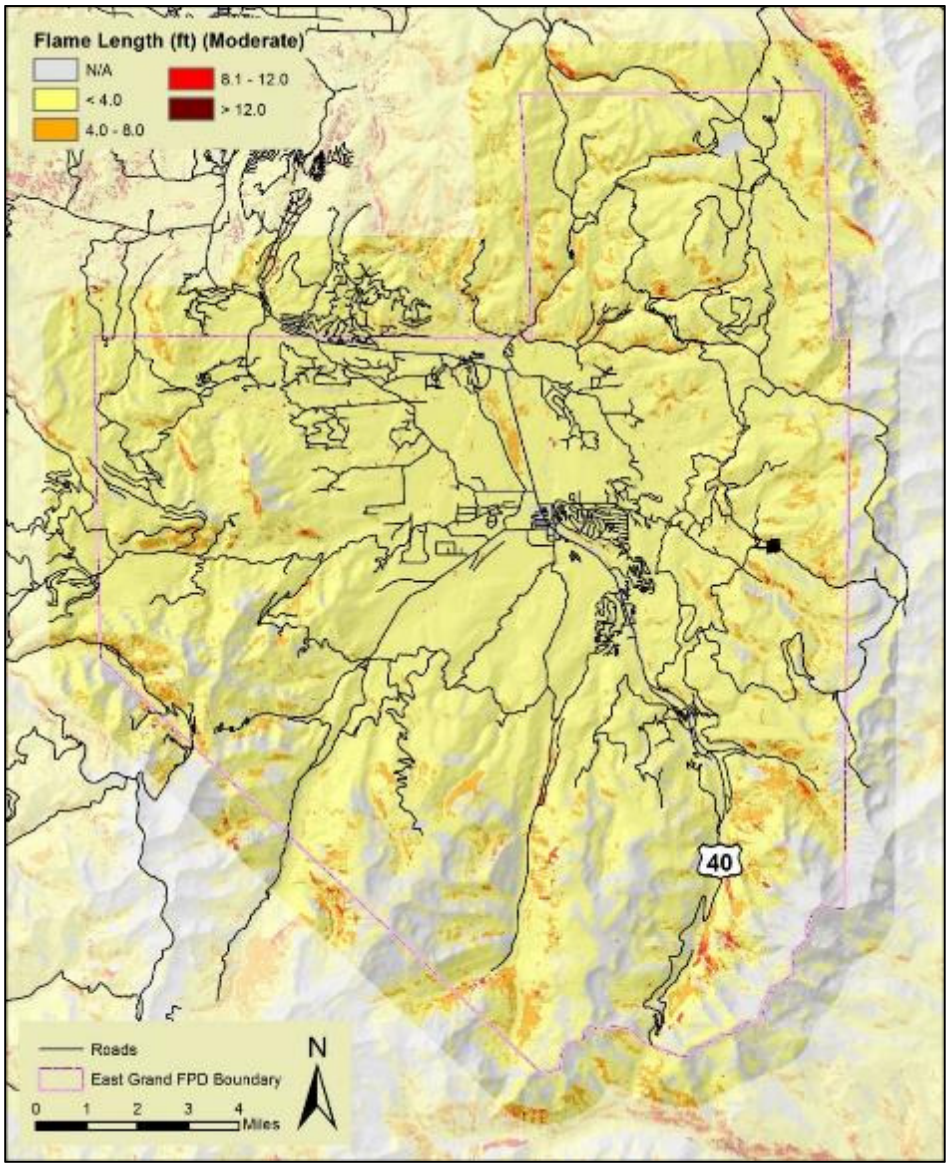

Figure 38. Predicted flame lengths under moderate weather conditions.

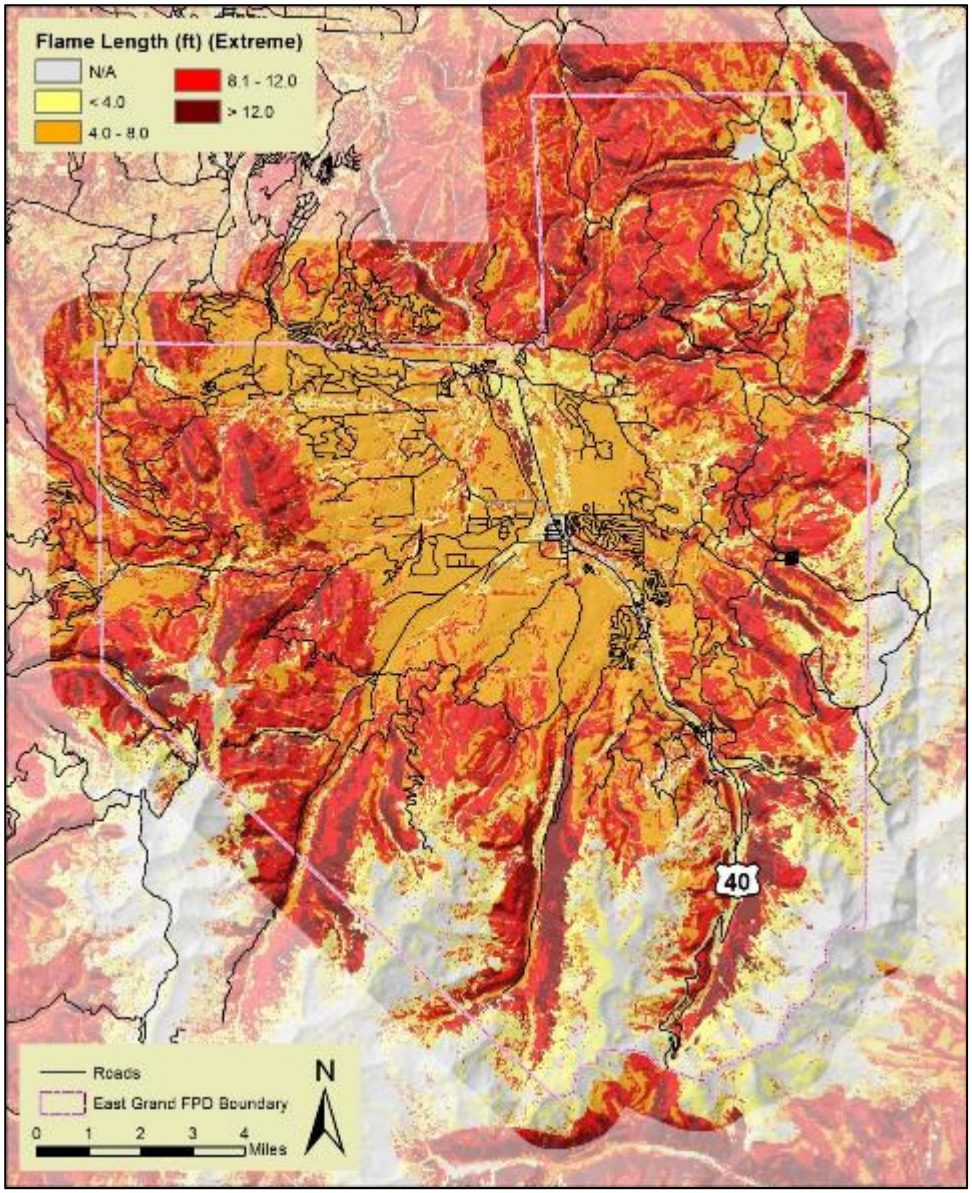

Figure 39. Predicted flame lengths under extreme weather conditions.

Crown Fire Potential

Crown fire activity values are generated by the FlamMap model and classified into four categories based on standard ranges: Active, Torching, Surface and Not Applicable. In the surface fire category, little or no tree torching will be expected. During passive crown fire activity, isolated torching of trees or groups of trees will be observed and canopy runs will be limited to short distances. During active crown fire activity, sustained runs through the canopy will be observed that may be independent of surface fire activity.

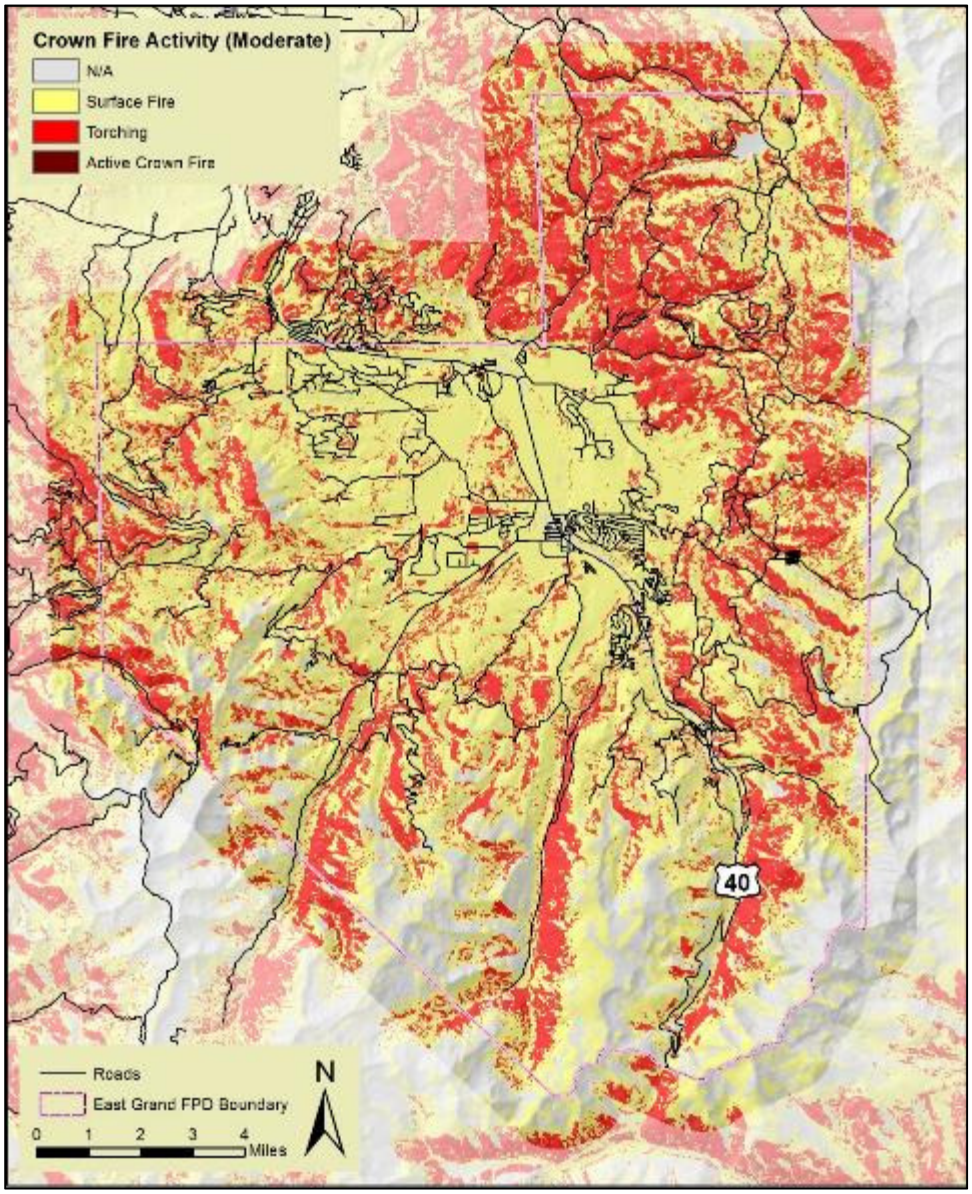

Figure 40. Predicted crown fire potential under moderate weather conditions.

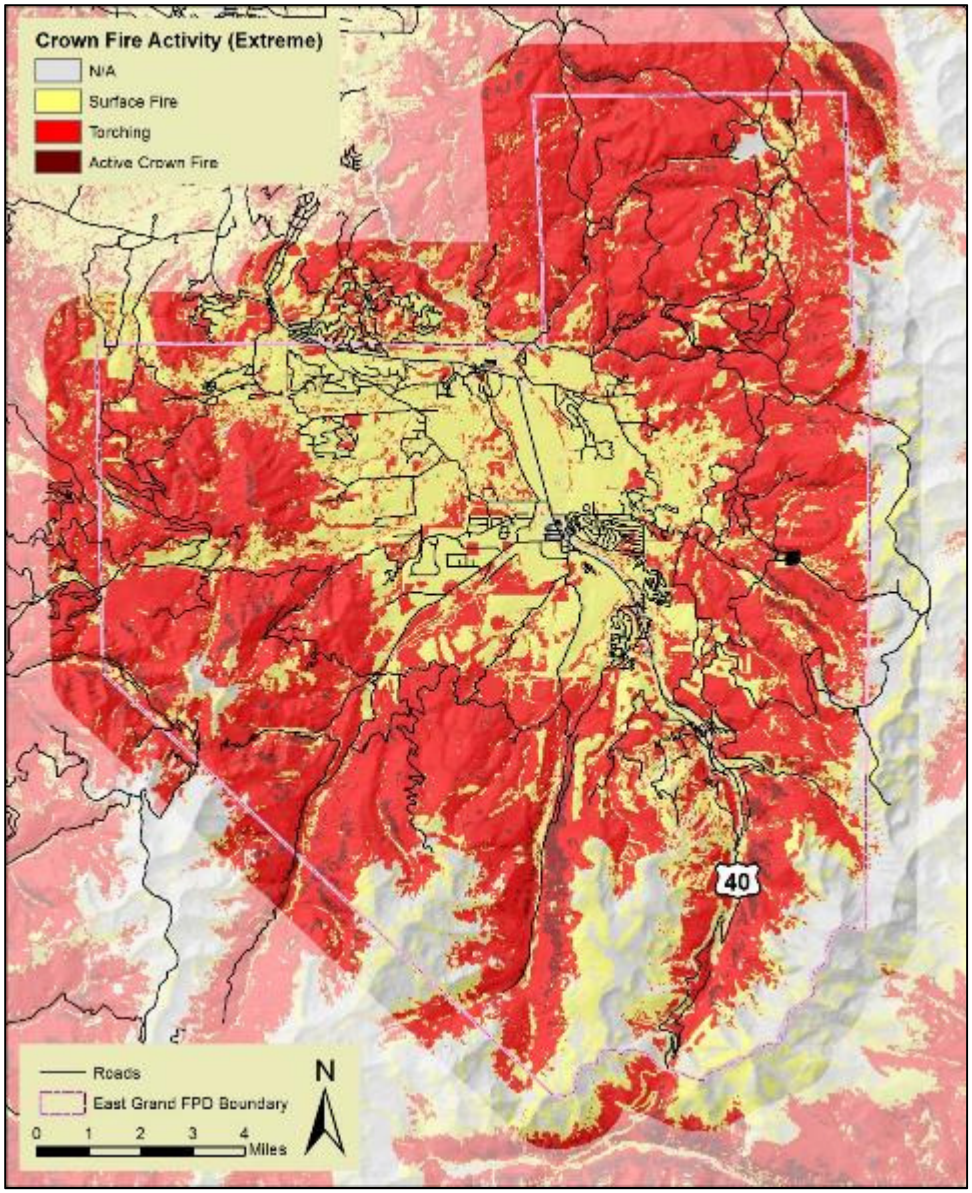

Figure 41. Predicted crown fire potential under extreme weather conditions.