Clear/Bear Creek Wildfire/Watershed Assessment

Prioritization of watershed-based risks to water supplies

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Additional information on the Clear/Bear Creek Wildfire/Watershed Assessment is available at:

http://www.jw-associates.org/clearbearcreek.html

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Clear/Bear Creek Wildfire/ Watershed Assessment

Prioritization of wildfire/watershed-based hazards to water supplies

INTRODUCTION

This watershed assessment is designed to identify and prioritize sixth-level watersheds based upon their hazards of generating flooding, debris flows and increased sediment yields following wildfires that could have impacts on water supplies. It is intended to expand upon current wildfire hazard reduction efforts by including water supply watersheds as a community value. The watershed assessment follows a procedure prescribed by the Front Range Watershed Protection Data Refinement Work Group (2009). This assessment also provides an identification of opportunities and constraints for each Zone of Concern.

Another goal of this assessment is to gather the key water supply stakeholders to communicate the suggested process, listen to any suggested changes, and build collaborative support for the assessment process. Four stakeholder meetings have included a diverse group of stakeholders (Appendix A) that have been engaged in the process.

WATERSHED DESCRIPTION

The Clear/Bear Creek watershed is a Front Range watershed that typically begins at the continental divide and ends at the start of the western edge of the plains. This watershed is a combination that includes Clear Creek, Bear Creek, and its tributaries that are all tributaries to the South Platte River. Bear Creek is currently classified

as part of the Upper South Platte watershed, but was not part of the Upper South Platte Watershed Assessment, previously completed. This watershed assessment is designed to assess hazards from wildfire to water supply. Therefore, the subwatersheds that are entirely on the plains, east of the foothills, were eliminated from this watershed assessment. The plains watersheds would have skewed the results of the assessment because they are relatively flat, have higher road densities and very different fire regimes.

The Clear/Bear Creek watershed is one fourth-level (eight-digit) watershed (HUC 10190004) and part of another fourth level watershed (HUC 10190002) that is 508,940 acres in size and contains 28 sixth-level watersheds. For this watershed assessment, four sixth-level watersheds were eliminated based upon their wildfire hazard, ruggedness, and an examination of how well they fit into this assessment. The Clear/Bear Creek watershed used in this analysis is 456,822 acres, contains five fifth-level watersheds and 24 sixth-level watersheds, which are the analysis units for this watershed assessment (Front Range Watershed Protection Data Refinement Work Group 2009). The Clear/Bear Creek watershed and its fifth-level and sixth-level watersheds are shown on Figure 1 and listed in Table 1

WATERSHED INTEGRITY/SUSTAINABILITY

Water supply watersheds have higher integrity or sustainability when they have more diverse vegetation. Forest diversity can be associated with a mix of species, amount of openings or a variety of age-classes of tree species. Many forested water supply watersheds in Colorado have become vulnerable to disturbance events because they have low diversity. In some cases low diversity is caused by fire suppression, past human caused disturbances, or may be their current condition without human-caused influences. Such is the case for many watersheds in Colorado currently forested with ponderosa pine and Douglas-fir, and those forested with lodgepole pine that have been heavily impacted by Mountain Pine Beetle (MPB).

Watershed conditions that are characterized by increasing forest density can present a high hazard to sustainable water supplies. High elevation forests are typically denser than low elevation forests. On a landscape scale, diversity in Colorado's high elevation forests has been reduced as meadows and openings are slowly filled by trees, forests move towards climax conditions, and successional aspen stands are converted to conifers. The openings and areas of lower density forest are important as these areas fill deeply with snow during winter and slowly release water during the spring and early summer. Areas of aspen, meadows and lower density forest also do not burn as intensely in wildfires, as densely forested areas. The current MPB epidemic has drastically altered this movement towards forests of greater density in many of these high elevation watersheds.

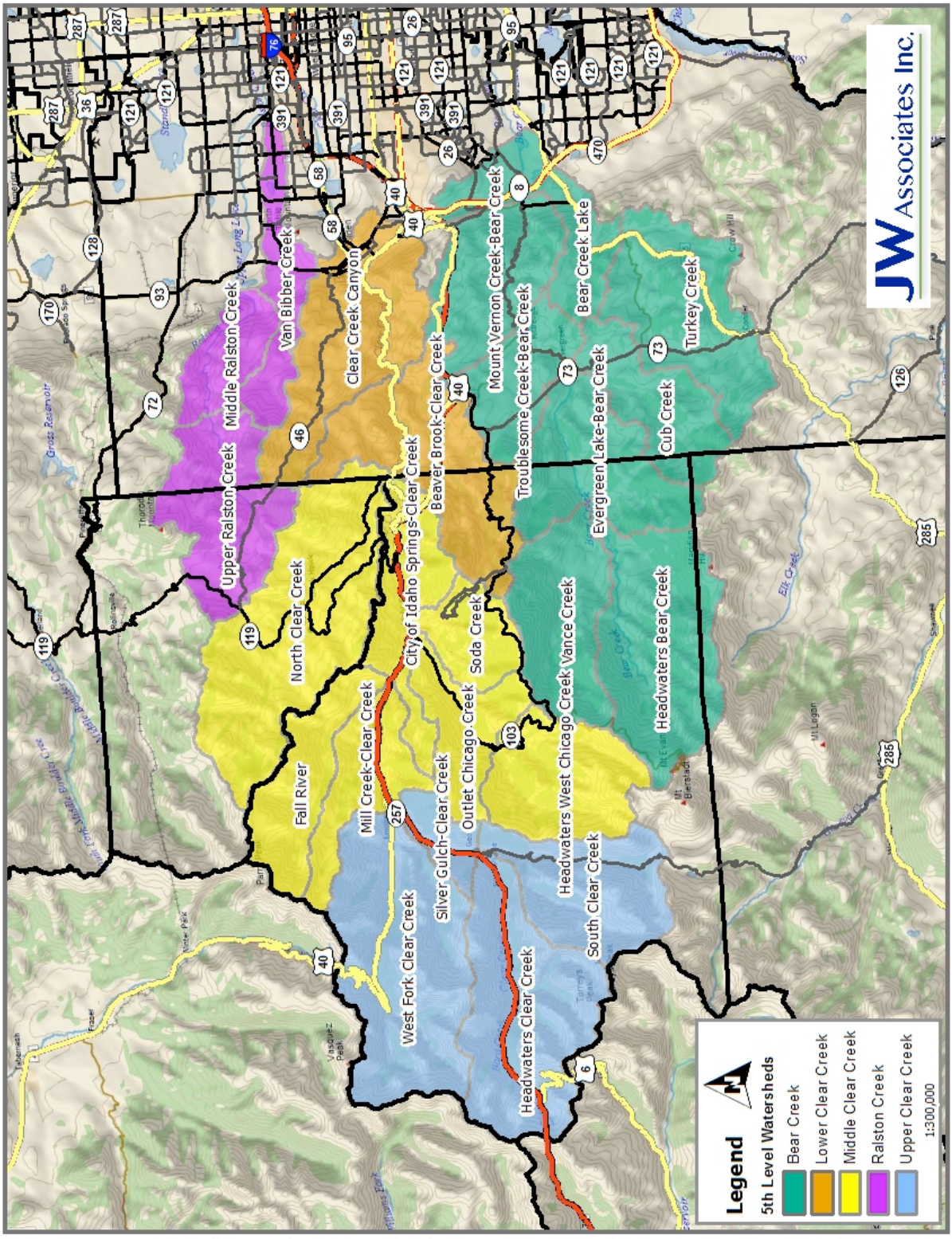

Figure 1. Clear/Bear Creek Watershed Analysis Area[1]

[1] The fifth-level watersheds are shown in the legend in Figure 1. The sixth-level watersheds can be seen in this figure outlined in gray lines and labeled.

Table 1. Fifth-level and Sixth-level Watersheds in Clear/Bear Creek Watershed

Fifth-level Watershed	Sixth-level Watershed	Watershed Area (acres)	Hydrologic Unit Code (HUC)
Bear Creek	Vance Creek	18,559	101900020801
HUC 1019000208	Headwaters Bear Creek	28,652	101900020802
	Evergreen Lake-Bear Creek	20,431	101900020803
	Cub Creek	14,241	101900020804
	Troublesome Creek-Bear Creek	12,667	101900020805
	Mount Vernon Creek-Bear Creek	17,719	101900020806
	Turkey Creek	24,197	101900020807
	Bear Creek Lake	14,445	101900020808
Upper Clear Creek	South Clear Creek	19,295	101900040101
HUC 1019000401	Headwaters Clear Creek	30,846	101900040102
	West Fork Clear Creek	36,752	101900040103
	Silver Gulch-Clear Creek	5,260	101900040104
Middle Clear Creek	Fall River	14,976	101900040201
HUC 1019000402	Mill Creek-Clear Creek	12,696	101900040202
	Headwaters West Chicago Creek	18,607	101900040203
	Outlet Chicago Creek	12,142	101900040204
	Soda Creek	8,941	101900040205
	North Clear Creek	38,491	101900040206
	City of Idaho Springs-Clear Creek	14,457	101900040207
Ralston Creek	Upper Ralston Creek	20,615	101900040301
HUC 1019000403	Middle Ralston Creek	8,973	101900040302
	Van Bibber Creek	11,357	101900040303
Lower Clear Creek	Beaver Brook-Clear Creek	26,222	101900040401
HUC 1019000404	Clear Creek Canyon	26,281	101900040402
	Total Area	**456,822**	

The pattern and amount of lodgepole pine regeneration will likely vary throughout the high country. If they regenerate primarily back to lodgepole pine, more landscape diversity will be lost because such stands will be of the same age and species. Management of these future stands through time can introduce much needed diversity at both the stand and landscape levels.

The montane forests of ponderosa pine and Douglas-fir in Colorado have been increasing in density partly due to fire suppression. These forests naturally have a mixed-severity fire regime that occurs at intervals between 20-35 years. That fire regime maintained a forest mosaic that was characterized by a mixture of openings, and patches of trees with variable density. Today, many of these montane forests are overly dense and have a high fire hazard due to the lack of openings and high tree canopy densities. These forests, that used to burn frequently with lower severity, have seen some of the most destructive wildfires in Colorado's history.

Fire ecologists use the term wildfire or burn severity to refer to the effects of fire on soil conditions and hydrologic function. Wildfire severity is the effect that fire has on ground cover and soils. High severity wildfires remove or kill virtually all living forest vegetation above the ground, including trees, shrubs and grasses, and consume fallen needles, decomposed roots and other elements of ground cover or duff that protect forest soils. Hot fires damage soil productivity by destroying organic materials in the soil, and can create hydrophobic conditions where rainfall will not readily soak into the soils. This phenomenon contributes to and increases erosion and the potential for debris flows. In general, the denser the pre-fire vegetation and the longer the fire burns on a particular site, the more severe the impacts on soil and its ability to absorb and process water.

The loss of critical surface vegetation leaves forested slopes extremely vulnerable to large-scale soil erosion and flooding during subsequent storm events. These risks threaten the communities and natural resources downstream, but can also adversely affect watershed integrity over the long-term. The presence of highly erosive soils in several parts of the state, and weather patterns that frequently bring heavy rains after the fire season can result in difficult and expensive challenges long-after the fires are out. For example, during the very severe Fire Year of 2002, at least 26 municipal water storage facilities were closed due to wildfire impacts. The South Platte River and Strontia Springs Reservoir are still experiencing the affects of that fire year.

Public and private entities have invested millions of dollars to implement emergency measures to protect people, communities and critical resources from post-fire events such as flooding, erosion, mudslides, and related degradation of water supplies and storage facilities. In the wake of the 2002 wildfire season, federal agencies invested more than $26 million in emergency rehabilitation, while at least $16 million was invested to shore-up non-federal lands. Denver Water and the Colorado State Forest Service undertook a massive post-fire rehabilitation effort at Cheesman Reservoir. Increasing forest diversity through active management of water supply watersheds can reduce the effects of wildfires on those watersheds.

WATERSHED ASSESSMENT

The potential of a watershed to deliver sediments following wildfire depends on forest and soil conditions, the configuration of the watersheds, and the sequence and magnitude of rain falling on the burned area. High-severity fires can cause changes in watershed conditions that can dramatically alter runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is affected by fire.

The Clear/Bear Creek Wildfire/Watershed Assessment considers four components that are integral in evaluating hazardous watershed conditions: wildfire hazard, flooding or debris flow hazard, soil erodibility and water supply. This section of the report presents the watershed assessment analysis that results in prioritization of sixth-level watersheds. It also discusses the technical approach for each component and the process used to assemble the watershed ranking.

The Clear/Bear Creek Wildfire/Watershed Assessment was developed through a stakeholder review process. The stakeholder group included representatives from water providers; federal, state and local land management agencies; counties; towns and other interested groups (Appendix A). Four stakeholder meetings were conducted to get the groups involved in the process, provide some local expertise to check and adjust the results and to understand how the assessment can be useful to the various stakeholder organizations.

The results for each component are categorized into five categories that are used in the analysis. The categorization is prescribed by the Colorado Watershed Protection Data Refinement Work Group (2009). The categories are used in this analysis for comparing watersheds to each other within the Clear/Bear Creek Watershed. Comparisons with other watershed assessments are not valid because this approach prioritizes watersheds by comparing them to the other sixth-level watersheds in this watershed assessment area.

The calculation of ranking for each sixth-level watershed is completed as follows:

1. Use the hazard based on the percentage of each sixth-level watershed (or other metrics).
2. Scale the results so that they fall within five equal categories.
3. Round the scaled result to the nearest whole number (retain the number for Composite Hazard Ranking).
4. Create a map of the results using the following scheme:

    Category 1 – Lowest
    Category 2
    Category 3
    Category 4
    Category 5 – Highest

Component 1 - Wildfire Hazard

The forest conditions that are of concern for the assessment are the dense forests that create high wildfire hazards. The wildfire hazard (Flame Length) was determined using the Fire Behavior Assessment Tool (FBAT) (http://www.fire.org) which is an interface between ArcMap and FlamMap. The input spatial data were collected from LANDFIRE project (http://www.landfire.gov/).

After a mountain pine beetle outbreak there are substantial increases in the amount of fine dead fuels in the canopy. The majority of these fuels remain in the canopy for 2-3 years post outbreak (Knight 1987, Schmid and Amman 1992). Therefore, certain input spatial data sets were updated based on Mountain Pine Beetle (MPB) mortality conditions using USDA Forest Service, Rocky Mountain Region Aerial Detection Survey (ADS) Data from the years 2002-2007 (http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/). The assumptions used in the FBAT model are presented in Appendix B.

The flame length results were divided into five categories of wildfire hazard ranging from lowest (Category 0) to highest (Category 4). The flame length categories that were used are;

Flame Length Category 0 - 0 meters

Flame Length Category 1 - 1 to 10 meters

Flame Length Category 2 - 11 to 25 meters

Flame Length Category 3 - 26 to 40 meters

Flame Length Category 4 - >40 meters

Figure 2 shows the results of the wildfire hazard modeling. The results were categorized by sixth-level watershed into five categories that are used throughout the analysis (see Table C-1 in Appendix C) using the following formula.

Wildfire Hazard Ranking = (Percentage in Category 2 + Percentage in Category 3 + Percentage in Category 4)

The categorized wildfire hazard by sixth-level watershed was mapped (Figure 3). The map shows that the highest hazards are in the following sixth-level watersheds: Soda Creek, Outlet Chicago Creek, Upper Ralston Creek, Silver Gulch-Clear Creek, Cub Creek, Evergreen Lake-Bear Creek, Mill Creek-Clear Creek, and Turkey Creek. Three watersheds were ranked as Category 4, which the next highest category. Therefore, nearly one-half of the watersheds were rated as Category 4 or 5 (see Table C-1 in Appendix C).

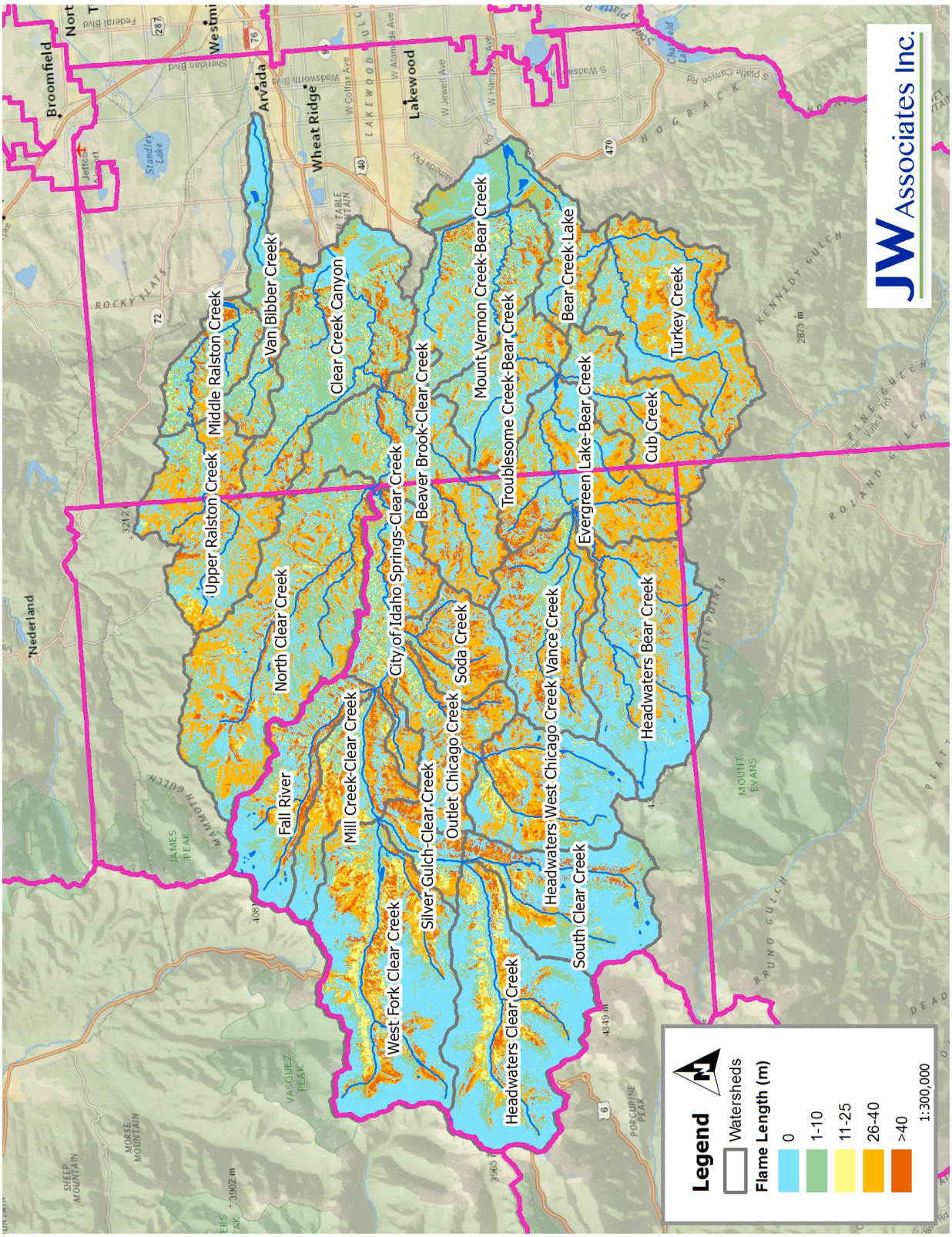

Figure 2. Clear/Bear Creek Watershed Wildfire Hazard Modeling Results

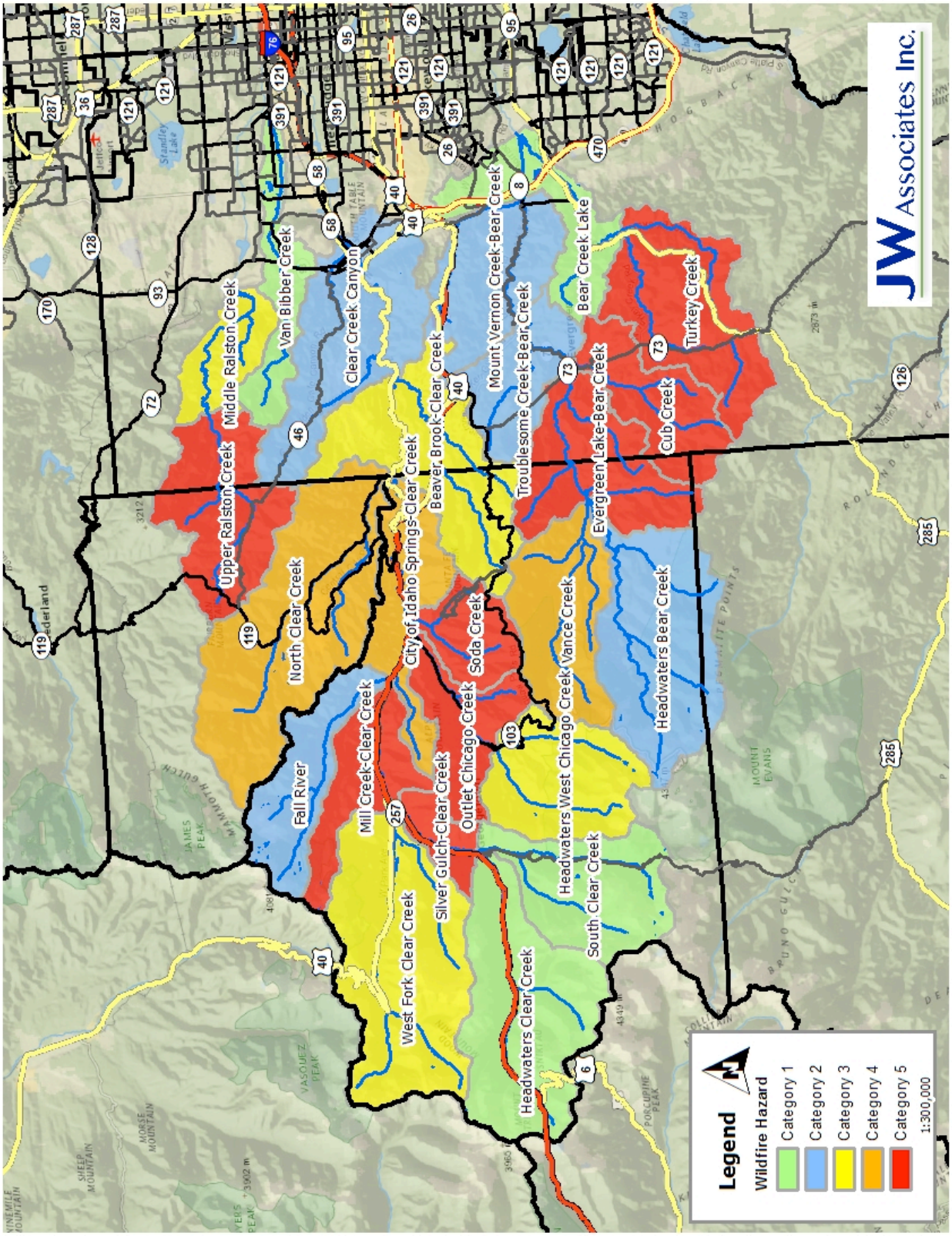

Figure 3. Clear/Bear Creek Watershed Wildfire Hazard Ranking

Tables 2 and 3 are provided as tools for interpreting the implications of the flame lengths presented in Figure 2. Ground crews with simple hand tools are not effective against fires with flame lengths over three to four feet. Spotting beyond the immediate vicinity of the fire causes safety concerns and can also result in several, if not numerous, independent fires downwind from the original blaze. Multiple spot fires can compromise firefighter and resident safety by cutting off escape routes to safety zones.

Table 2. Fire Suppression Implications of Flame Length

Flame Length (feet)	Interpretation
0-4	Persons using hand tools can generally attack fires at the head or the flanks. Handlines should hold the fire.
4-8	Fires are too intense at the head for direct attack by persons using hand tools. Handlines can't be relied upon to hold the fire. Equipment such as dozers, engines and retardant aircraft can often be effective on fires with these flame lengths.
8-11	Fires with these flame lengths may present serious control problems such as torching, crowning, and spotting. Control efforts at the head of the fire using dozers and engines will probably be ineffective. Attack using retardant aircraft may still be effective.
11+	Crowning, spotting, and major fire runs are common. Control efforts at the head of the fire, even with retardant aircraft, are usually ineffective.

Table 3. Rate of Spread Based on Flame Length[2]

Flame Length (feet)	Rate of Spread (Chains/Hour)
0 – 1	0 – 2
1 – 4	2 – 5
4 – 8	5 – 20
8 – 11	20 – 50
12 – 25	50 – 150
> 25	> 150

[2] One chain equals 66 feet

Component 2 - Flooding or Debris Flow Hazard

A combination of ruggedness and road density (miles of road per square mile of watershed area) was used to assess the flooding or debris flow hazard portion of the analysis. The two components, ruggedness and road density, are described below.

Ruggedness

Watershed steepness or ruggedness is an indicator of the relative sensitivity to debris flows following wildfires (Cannon and Reneau 2000). The more rugged the watershed, the higher its sensitivity to generating debris flows following wildfire (Melton 1957). The Melton ruggedness factor is basically a slope index.

Melton (1957) defines ruggedness, R, as;

$$R = H_b A_b^{-0.5}$$

Where A_b is basin area and H_b is basin height measured from the point of highest elevation along the watershed divide to the outlet.

The ruggedness result in some watersheds was adjusted because they do not accurately reflect the slope in those watersheds. Those situations are most common in composite watersheds because they are disconnected from their headwaters. These watersheds can have a high hazard for debris flows because they contain a main stem of a creek or river with several steep first order streams as tributaries. In those situations, the ruggedness calculation was adjusted up by reducing the watershed area. These adjustments were completed on the Evergreen Lake-Bear Creek, Troublesome Creek-Bear Creek, Mount Vernon Creek-Bear Creek, Bear Creek Lake, Outlet Chicago Creek, North Clear Creek, City of Idaho Springs-Clear Creek, Middle Ralston Creek, Beaver Brook-Clear Creek, and Clear Creek Canyon watersheds. The Silver Gulch-Clear Creek watershed was skewing the categorization because of its high ruggedness value and was manually given a score slightly higher than the next highest score (Appendix C).

Figure 4 displays the categorized ruggedness for the Clear/Bear Creek Watershed. The map generally shows that while much of the watershed is quite steep, the watersheds east of the foothills are much flatter than the others. The tabular results are presented in Appendix C. The map (Figure 4) shows that the most rugged sixth-level watersheds are; Silver Gulch-Clear Creek, Mill Creek-Clear Creek, Fall River, and Outlet Chicago Creek. The upper portions of the watershed are steeper than the lower portions in general.

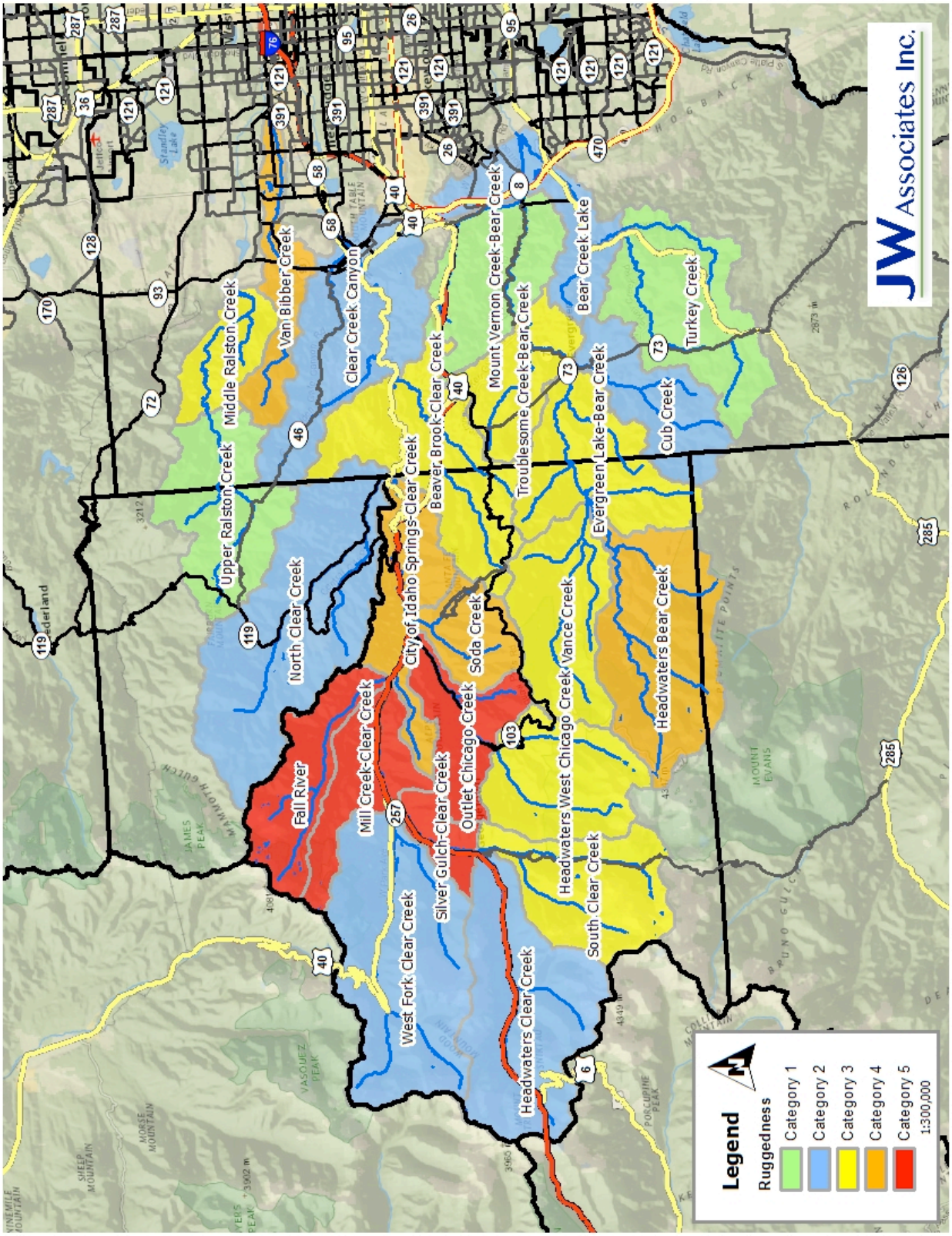

Figure 4. Clear/Bear Creek Watershed Ruggedness Ranking

Road Density

Roads can convert subsurface runoff to surface runoff and then route the surface runoff to stream channels, increasing peak flows (Megan and Kidd 1972, Ice 1985, and Swanson et al. 1987). Therefore, watersheds with higher road densities have a higher sensitivity to increases in peak flows following wildfires. Road density in miles of road per square mile of watershed area was used as an indicator of flooding hazard. The U.S. Forest Service roads data was used on National Forest System (NFS) lands because it is the most accurate roads data for those roads in the forest. On all other lands the U.S. Census Bureau's Tiger database was used because it is a consistent roads data layer (Figure 5).

Road densities were adjusted in some watersheds where some of the roads within a watershed were within towns, developed areas, or outside the forested areas of the watershed. The roads that are of interest in this analysis are those roads that would increase the risk of flooding or debris flows following wildfires in forested areas. The watersheds were all examined by looking at the roads data overlain on digital images and vegetation mapping. If it was found that there were significant lengths of road outside forested areas, the road density in those watersheds was adjusted down based on ocular estimates.

Road density in Troublesome Creek-Bear Creek, Bear Creek Lake, Headwaters Clear Creek, Silver Gulch-Clear Creek, City of Idaho Springs-Clear Creek, and Van Bibber Creek watersheds were all adjusted down because they contain towns or housing developments that display very high road density or have road systems outside of the forest. The adjustments are displayed on Table C-3 in Appendix C.

Figure 6 displays the categorized road density for the Clear/Bear Creek Watershed and tabular results are presented in Appendix C. It displays some expected differences in road density throughout the watershed. Figure 6 shows that the highest rankings are in the Mill Creek-Clear Creek, Cub Creek, Turkey Creek, Soda Creek, Outlet Chicago Creek, Mount Vernon Creek-Bear Creek, and City of Idaho Springs-Clear Creek watersheds.

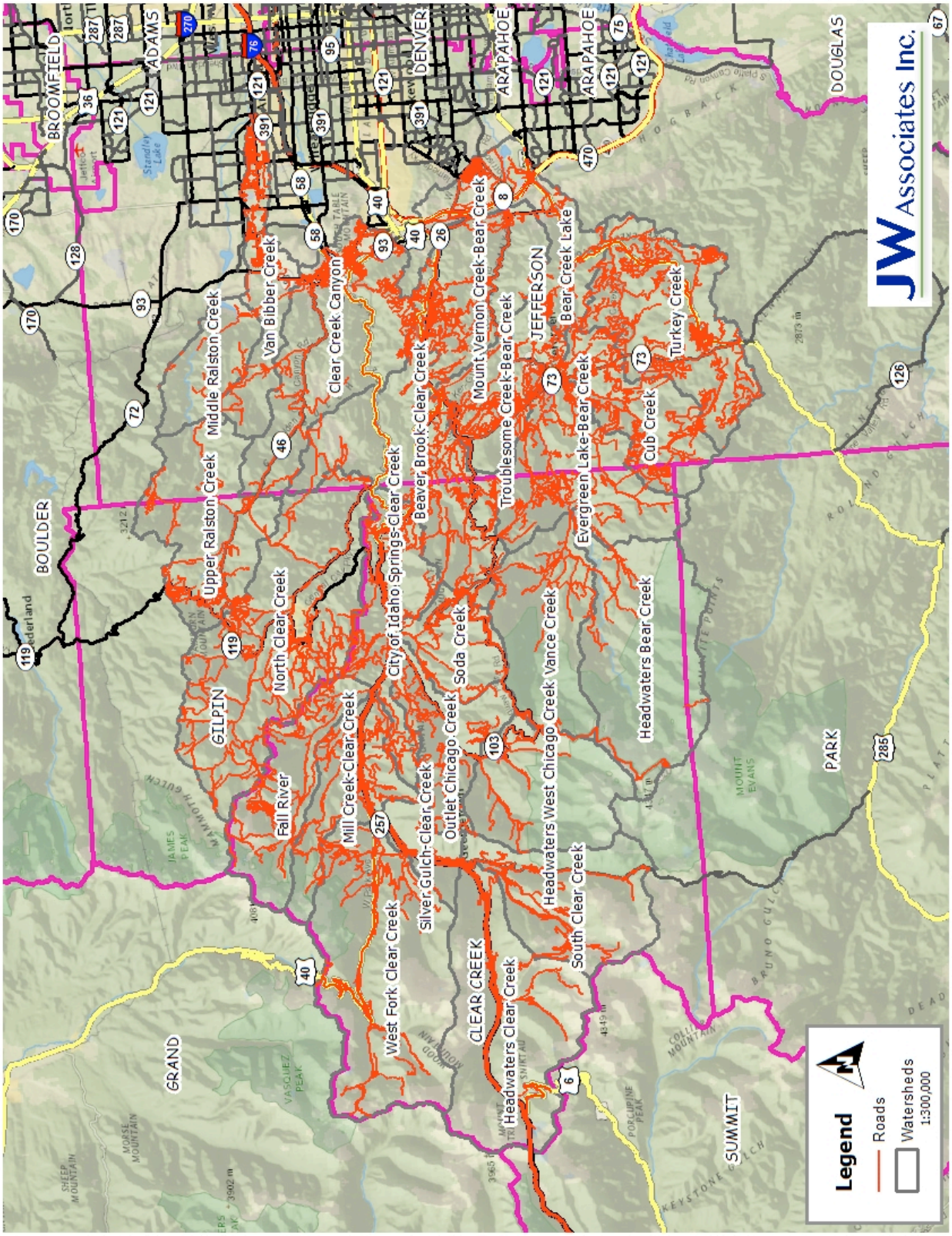

Figure 5. Clear/Bear Creek Watershed Roads Map

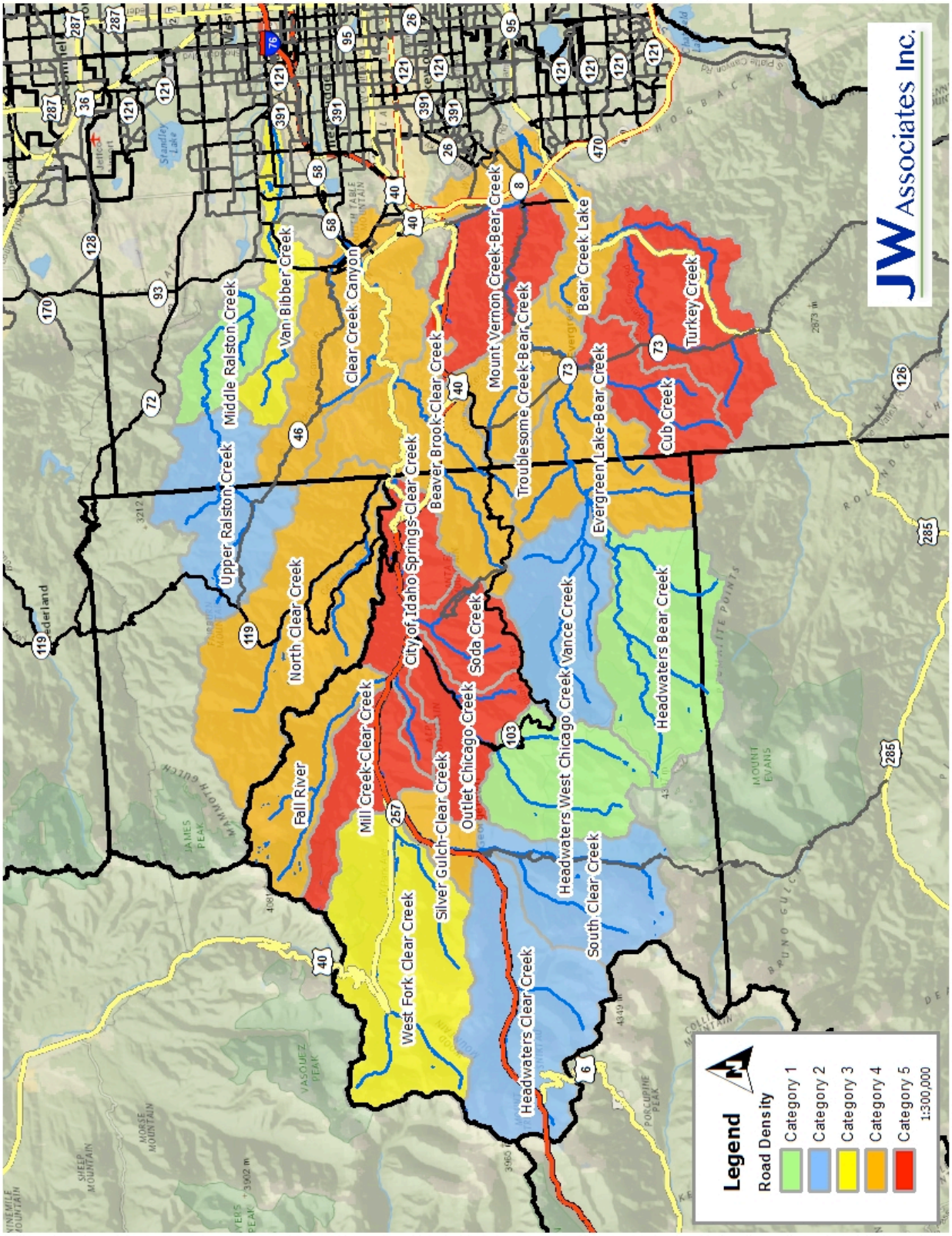

Figure 6. Clear/Bear Creek Watershed Road Density Ranking

Flooding or Debris Flow Hazard Ranking

The Flooding or Debris Flow Hazard is the combination of ruggedness and road density. The procedure from the Colorado Watershed Work Group (2009) assigned ruggedness a higher value than road density in this ranking. While ruggedness is the most important factor, an increase in road density will magnify the effects of ruggedness on the flooding/debris flow hazard. Accordingly, the analysis for flooding or debris flow hazard for the Clear/Bear Creek watershed used the following formula. The results of this calculation were then re-categorized into five hazard rankings.

Flooding or Debris Flow Hazard Ranking = (Road Density Ranking + Ruggedness Ranking ***** 2)

The stakeholder group identified two watersheds that have significant historic mining that the group concluded would raise the flooding or debris flow hazard ranking. Those two watersheds are Headwaters Clear Creek and North Clear Creek. The Upper Clear Creek Watershed Plan (Upper Clear Creek Watershed Association 2006) confirmed that these watersheds have extensive historic mining impacts. The Mill Creek-Clear Creek watershed was skewing the categorization because of its high flooding or debris flow hazard ranking value and was manually given a score slightly higher than the next highest score (Appendix C).

Figure 7 shows that areas of the watershed with high road densities and high ruggedness rank high in this combined factor. The best way to look at this map is to look at a single watershed on the ruggedness and road density maps, noting the rankings on each. Then look at this map and see how they result in the final ranking for this component. The tabular results are presented in Table C-4 in Appendix C. The highest ranked sixth-level watersheds are Mill Creek-Clear Creek, Silver Gulch-Clear Creek, Fall River, Outlet Chicago Creek, Soda Creek, and City of Idaho Springs-Clear Creek.

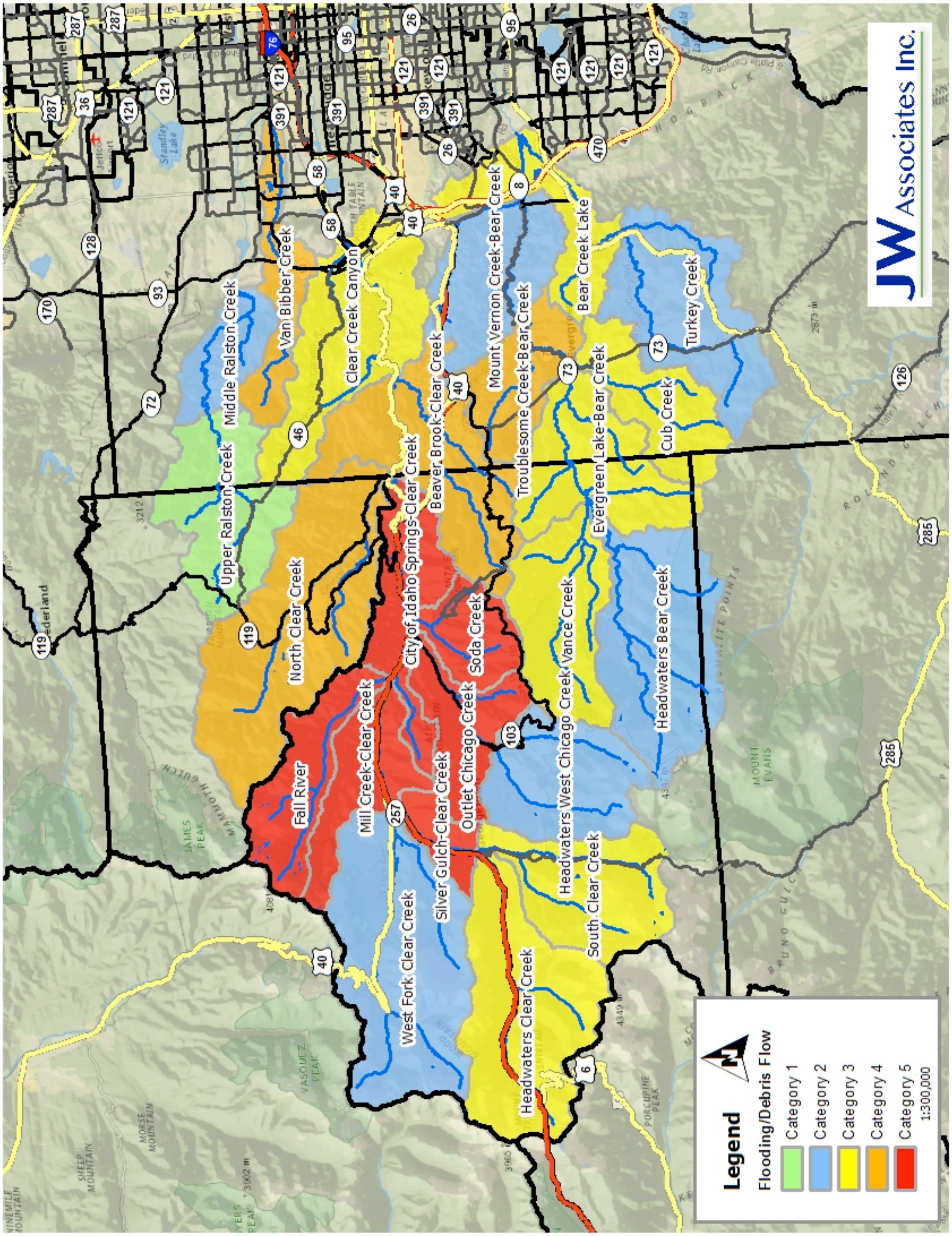

Figure 7. Clear/Bear Creek Watershed Flooding/Debris Flow Hazard Ranking

Component 3 - Soil Erodibility

High-severity fires can cause changes in watershed components that can dramatically change runoff and erosion processes in watersheds. Water and sediment yields may increase as more of the forest floor is consumed (Wells et al. 1979, Robichaud and Waldrop 1994, Soto et al. 1994, Neary et al. 2005, and Moody et al. 2008) and soil properties are altered by soil heating (Hungerford et al. 1991).

Two soils data sets were evaluated for use in this analysis, the U.S.D.A. - Natural Resources Conservation Service (NRCS) STATSGO and SSURGO soils data. STATSGO data are relatively coarse soils data, created at a scale of 1:250,000 and are available for the entire watershed assessment area. SSURGO soils data do not cover all the watershed assessment area, though efforts by the NRCS are currently under way to produce an updated soils data layer. The data used in this analysis is the SSURGO soils data combined with the U.S. Forest Service soils data. SSURGO data does not cover all watersheds but is available at a better scale (generally ranges from 1:12,000 to 1:63,360) than STATSGO data. The U.S. Forest Service soils data is comparable with the SSURGO data in scale and quality. Areas without SSURGO data were filled in with U.S. Forest Service data (Figure 8).

The soil erodibility analysis used a combination of two standard erodibility indicators: the inherent susceptibility of soil to erosion (K factor) and land slope derived from Unites States Geological Survey (USGS) 30-meter digital elevation models. The K factor data from the STATSGO spatial database was combined with a slope grid using NRCS (USDA NRCS 1997) slope-soil relationships (Table 4) to create a classification grid divided into slight, moderate, severe and very severe erosion hazard ratings.

Table 4. NRCS Criteria for Determining Potential Soil Erodibility

Percent Slope	K Factor <0.1	K Factor 0.1 to 0.19	K Factor 0.2 to 0.32	K Factor >0.32
0-14	Slight	Slight	Slight	Moderate
15-34	Slight	Slight	Moderate	Severe
35-50	Slight	Moderate	Severe	Very Severe
>50	Moderate	Severe	Very Severe	Very Severe

The potential soil erodibility hazard rankings are shown on Figure 9 and the tabular results are presented in Appendix C. The Vance Creek, Headwaters Bear Creek, Evergreen Lake-Bear Creek, Cub Creek, Troublesome Creek-Bear Creek, Mount Vernon Creek-Bear Creek, and Turkey Creek watersheds were adjusted up one category in ranking due to the presence of granitic parent material that has higher erodibility than the K-factor value represents. The highest ranked sixth-level watersheds are Silver Gulch-Clear Creek, and Vance Creek. The Silver Gulch-Clear Creek watershed was skewing the categorization because of its high soil erodibility value and was manually given a score slightly higher than the next highest score (Appendix C).

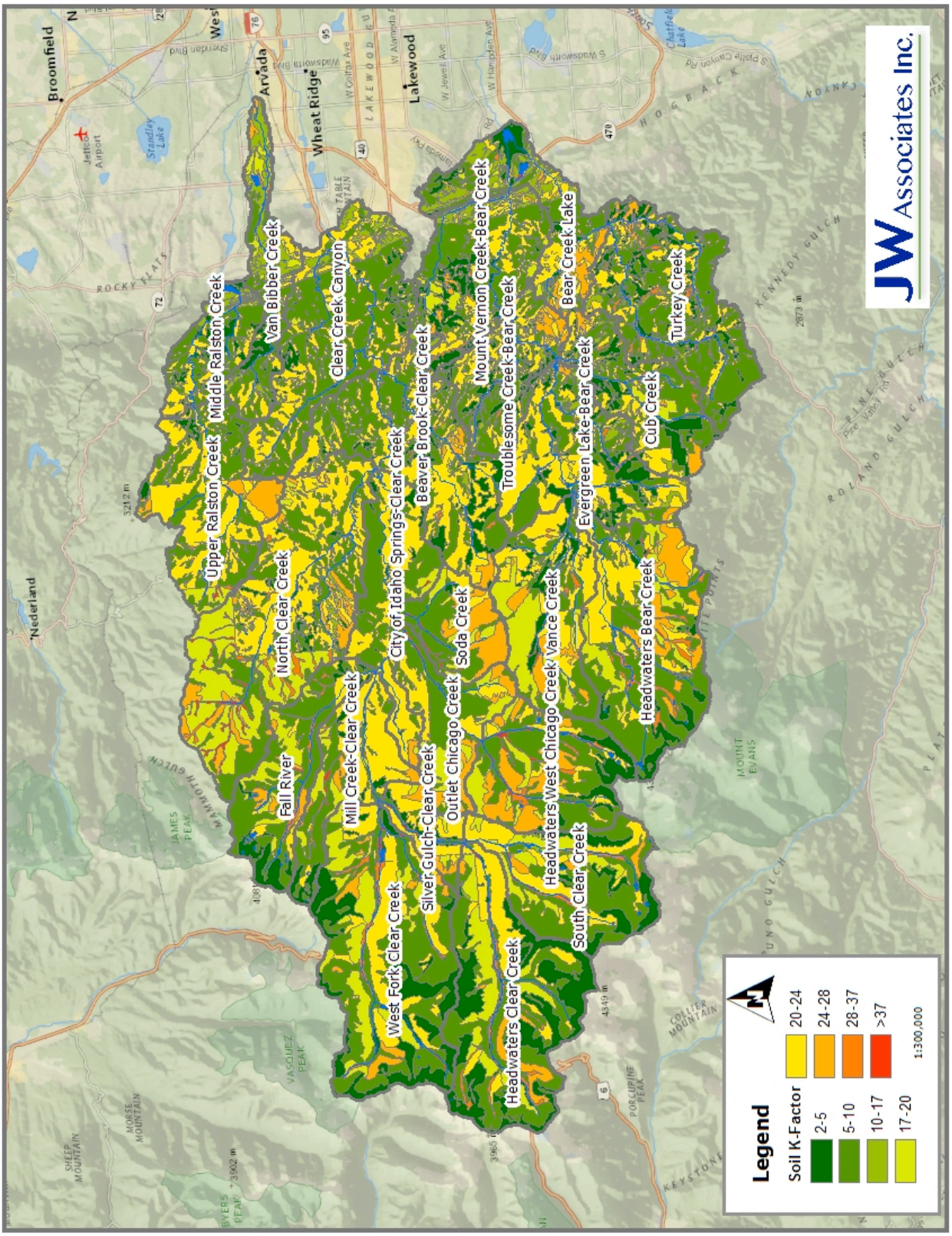

Figure 8. Clear/Bear Creek Watershed Soils K-Factor Map

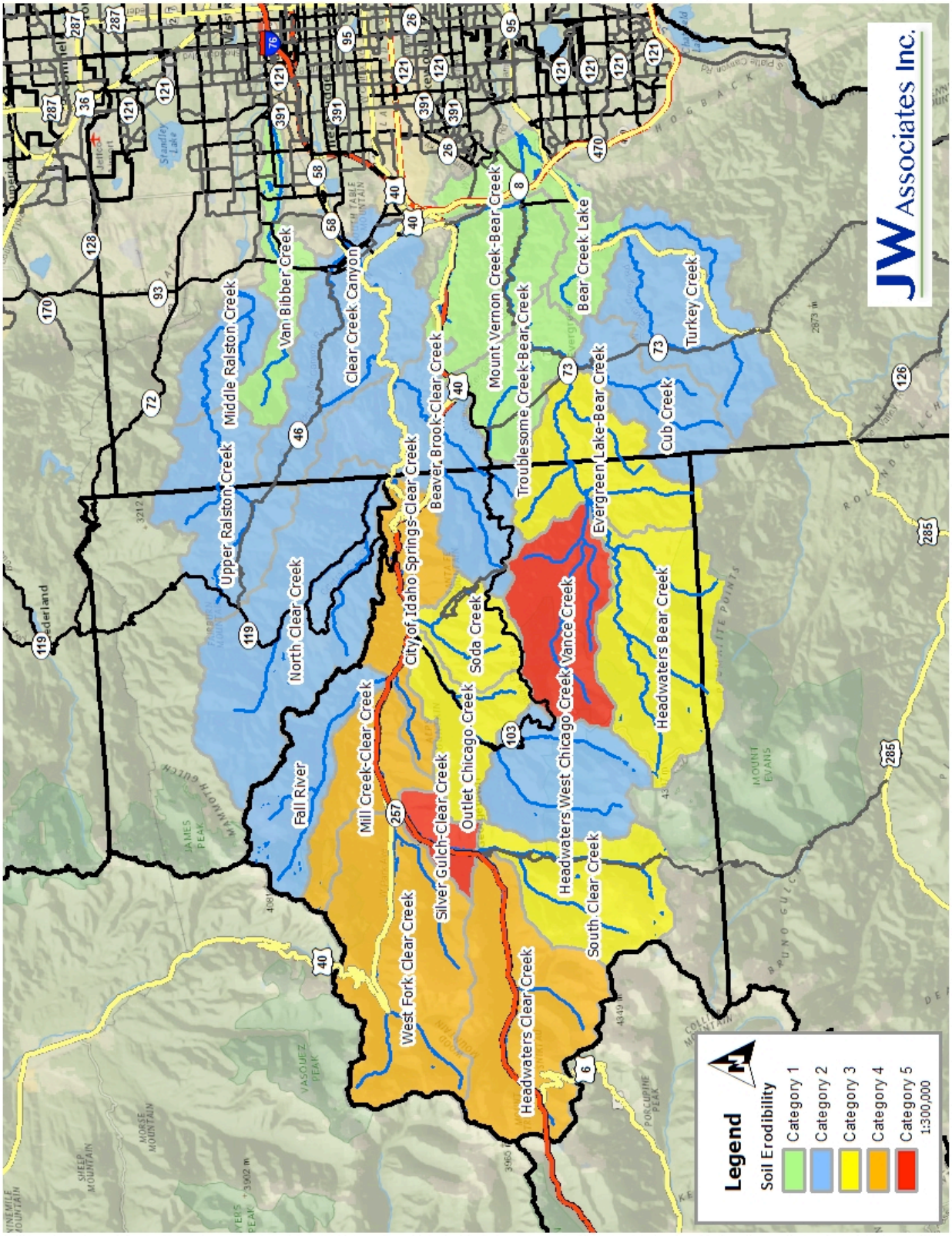

Figure 9. Clear/Bear Creek Watershed Potential Soil Erodibility Hazard Ranking

Composite Hazard Ranking

The Composite Hazard Ranking combines the first three components (Wildfire Hazard, Flooding/Debris Flow Hazard and Soil Erodibility) by numerically combining their rankings for each sixth-level watershed and then re-categorizing the results. The Composite Hazard Ranking map is useful in comparing relative watershed hazards based solely on environmental factors. Figure 10 shows the Composite Hazard Ranking for the Clear/Bear Creek Watershed. The tabular results that display the rankings for Wildfire Hazard, Flooding/Debris Flow Hazard and Soil Erodibility, as well as the composite rankings are presented in Table C-6 in Appendix C. The highest ranked sixth-level watersheds are Silver Gulch-Clear Creek, Mill Creek-Clear Creek, Soda Creek, Outlet Chicago Creek, and City of Idaho Springs-Clear Creek. Additionally, there are two watersheds in Category 4.

Component 4 - Water Supply Ranking

Surface water intakes, diversions, conveyance structures, storage reservoirs and streams are all susceptible to the effects of wildfires. The suggested approach from the procedure prescribed by the Colorado Watershed Protection Data Refinement Work Group (2009) is to first rank watersheds based upon the presence of water supply locations.

Surface drinking water supply collection points from the Source Water Assessment and Protection (SWAP) Program (see http://www.cdphe.state.co.us/wq/sw/swaphom.html for basic information on the SWAP Program) were used to identify which sixth-level watersheds that contain critical components of the public water supply infrastructure in Colorado. For this assessment, water nodes were defined as coordinate points corresponding to surface water intakes, upstream diversion points and classified drinking water reservoirs.

Water supply locations may not be identified in the state's database for some drinking water supply reservoirs that do not have associated direct surface water intakes. Also, some water supply reservoirs may not be identified in the SWAP database. The Water Supply map was modified to include these features by including all named reservoirs and important water supply infrastructure identified by the stakeholders.

Figure 11 shows the sixth-level watersheds that have water supply locations in blue and those without water supply locations in green.

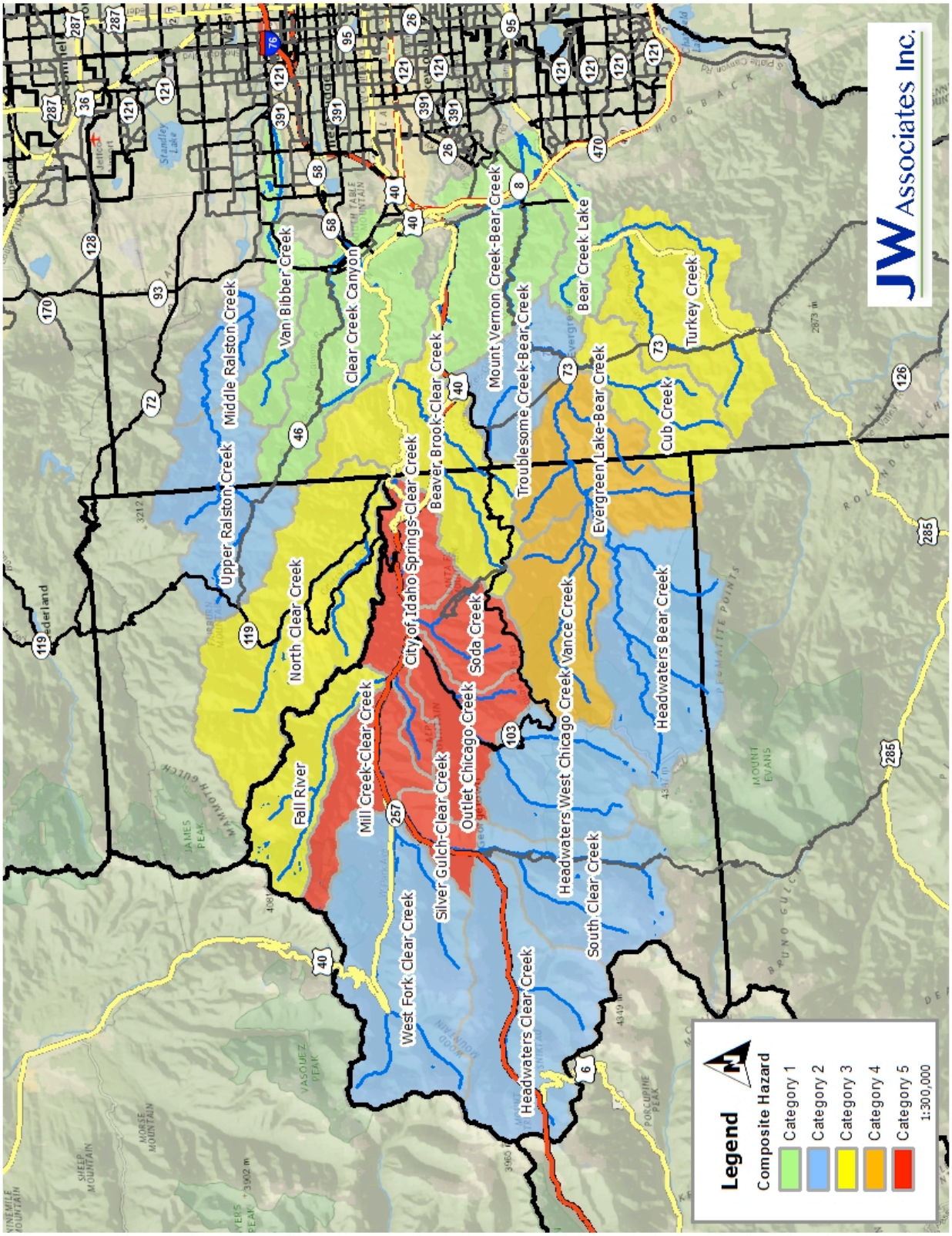

Figure 10. Clear/Bear Creek Watershed Composite Hazard Ranking

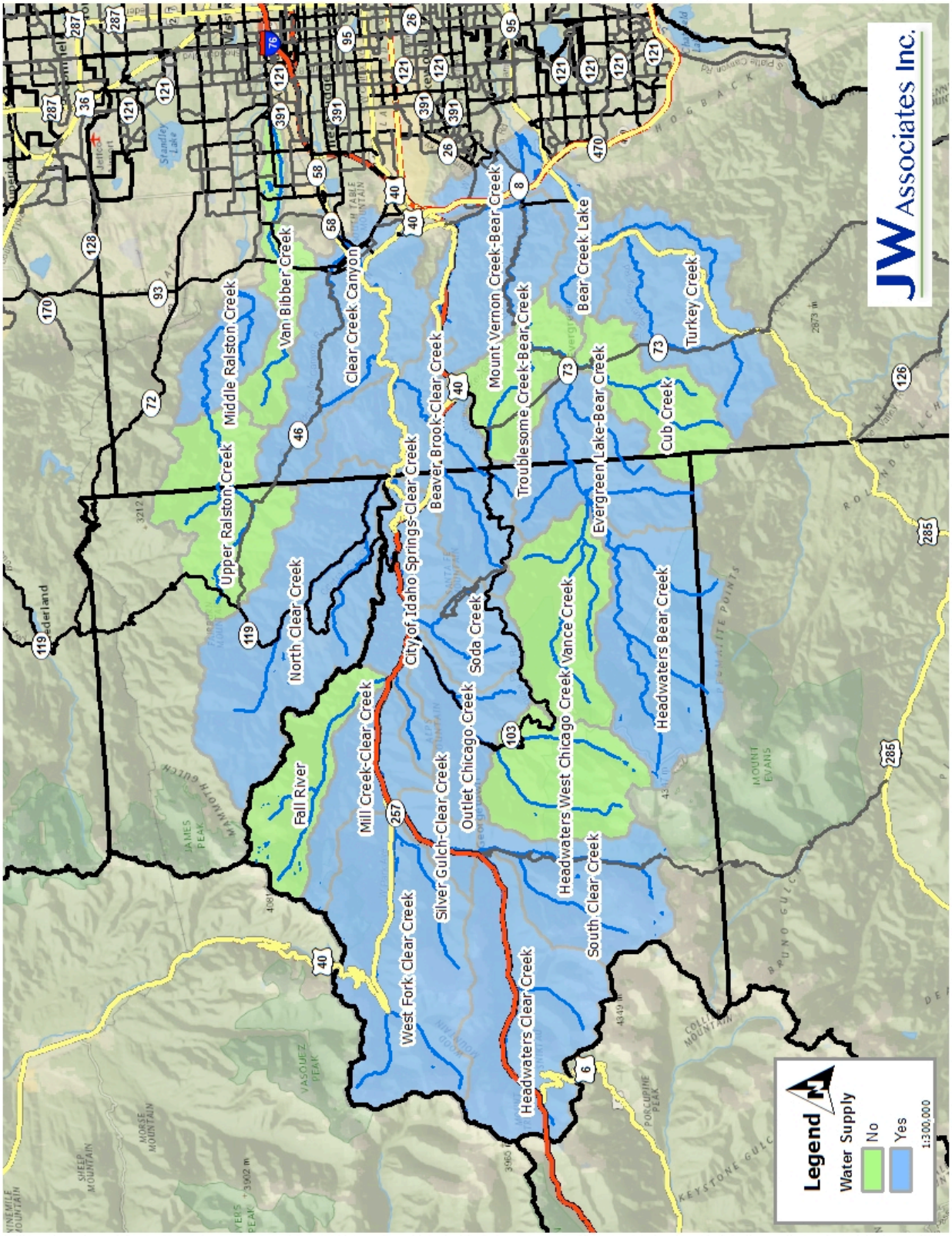

Figure 11. Clear/Bear Creek Watershed Water Supply Map

Final Priority

Those watersheds that have a water supply feature (diversion, reservoir or other) were given higher priority in the final ranking scheme by increasing their priorities from the Composite Hazard map by one category. Those results were then re-categorized into five categories. The final priority combines the hazards of wildfires, flooding/debris flows, soil erodibility and the presence of water supply features. The final priority rankings are shown on the Final Priority map (Figure 12). The sixth-level watersheds that ranked highest on the Final Priority map are Silver Gulch-Clear Creek, Mill Creek-Clear Creek, Soda Creek, Outlet Chicago Creek, and City of Idaho Springs-Clear Creek. The Evergreen Lake-Bear Creek watershed was the only Category 4 watershed.

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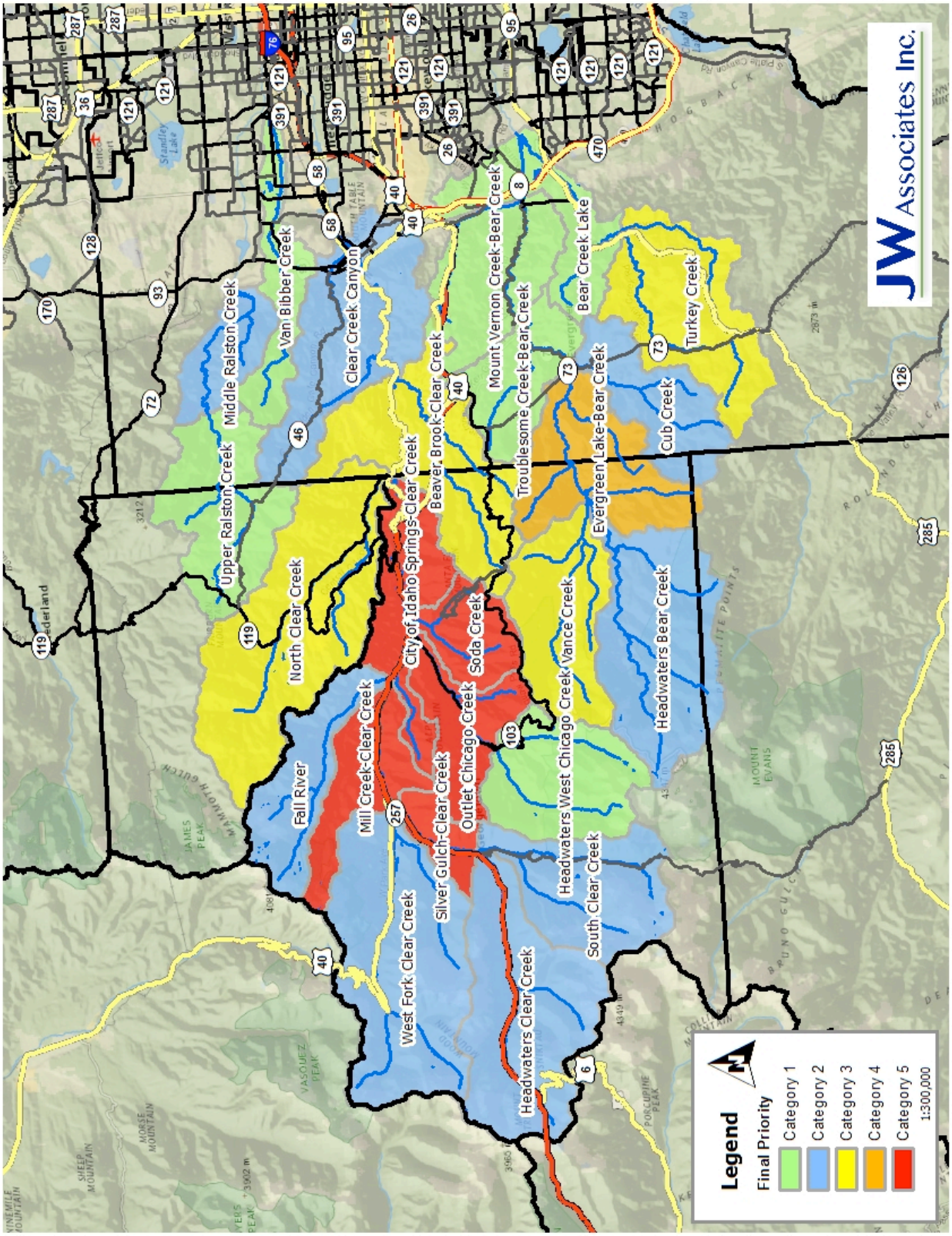


Figure 12. Clear/Bear Creek Watershed Final Priority

Zones of Concern

The Watershed Wildfire Protection Group identified an important hazard for water supply related to transport of debris and sediment from upstream source water areas. The source water areas (i.e. watershed areas) above important surface water intakes, upstream diversion points and drinking water supply reservoirs have a higher potential for contributing significant sediment or debris. These areas, called Zones of Concern (ZoC), can be used by stakeholders to further define project areas for protection planning and actions.

There were several methods suggested by the Colorado Watershed Protection Data Refinement Work Group (2009) to define ZoC. The Clear/Bear Creek Watershed Stakeholders initially agreed to use the five-mile upstream distance. This approach is based on Colorado State Statute 31-15-707 which allows municipal water providers to enact an ordinance to protect their water intakes within five miles upstream of their intakes. This municipal statute has been in place since the late 1800s and has been tested in court several times and upheld.

Many of the ZoC stopped at a watershed divide before they reached the five mile upstream distance. The Watershed Wildfire Protection Group suggested that extending Zones of Concern to 11 miles upstream in situations where the extra protection appears warranted. There are several important diversions and reservoirs that are positioned lower in the watershed. During the third stakeholder meeting, the group suggested that the ZoC be extended to 11 miles upstream for ZoC above Evergreen Lake, Ralston Reservoir, and Lower Clear Creek. The debris flow and flooding following the Buffalo Creek fire in the Upper South Platte watershed in 1996 traveled 11 miles down Spring Creek (Colorado Watershed Protection Data Refinement Work Group 2009). These ZoC were added as separate areas covering from five to 11 miles upstream, or to where they encountered the watershed divide.

Stakeholder groups may want to expand their Zones of Concern to include all the sixth-level watersheds that have any portion of those watersheds within their Zone of Concern. Erosion, flooding and debris flows can originate high in watersheds and travel long distances. Decisions of what areas to include would be made at the next level in planning (see Recommendations section below).

Thirty-three ZoC within five miles upstream of diversions and reservoirs were delineated in the Clear/Bear Creek Watershed (Figure 13 and Table 5) totaling more than 190,000 acres. Four of the ZoC were extended to 11 miles upstream increasing the total ZoC area to more than 228,000 acres. The ZoC were overlaid on the Final Priority map (Figure 13). More detailed maps of the ZoC are presented in the Opportunities & Constraints section below. The water supply agencies for each ZoC have also been identified in Table 5. Some of the ZoC overlap with others, or in other areas, the ZoC are close to overlapping other ZoC. In those situations, ZoC can be combined or viewed as one, combining several stakeholders into a larger ZoC.

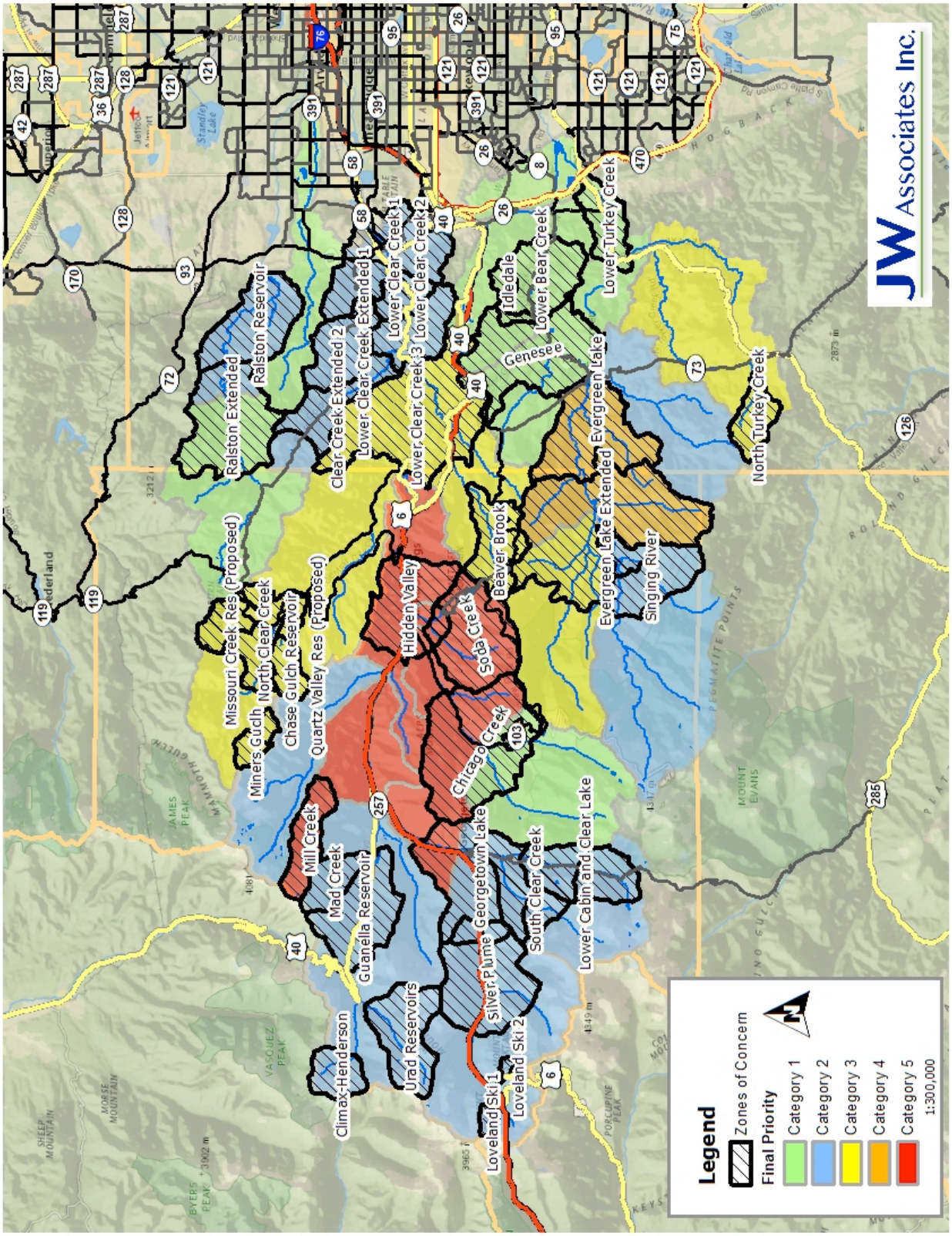


Figure 13. Clear/Bear Creek Watershed Zones of Concern

Table 5. Clear/Bear Creek Watershed Zones of Concern[3]

Name	0-5 Mile ZoC (acres)	5-11 Mile ZoC (acres)	Total ZoC Area (acres)	Drinking Water Supply Impacted
Beaver Brook	4,888		4,888	Lookout Mountain WD
Broomfield Gulch	73		73	City of Central City
Chase Gulch Reservoir	1,897		1,897	City of Central City
Chicago Creek	13,585		13,585	City of Idaho Springs
Climax-Henderson	2,509		2,509	Climax-Henderson Mine
Evergreen Lake	8,521	20,239	28,760	Evergreen Metro District
Genesee	11,413		11,413	Genesee W&SD
Georgetown Lake	11,692		11,692	Various
Guanella Reservoir	6,939		6,939	City of Golden
Hidden Valley	7,790		7,790	City of Black Hawk
Idledale	867		867	Idledale W&SD
Loveland Ski 1	536		536	Loveland Valley Ski Company
Loveland Ski 2	262		262	Loveland Valley Ski Company
Lower Bear Creek	6,567		6,567	Town of Morrison
Lower Cabin & Clear Lake	6,273		6,273	Public Service Company of Colorado
Lower Clear Creek 1	11,979	4,709	16,688	City of Golden, City of Arvada, Standley Lake Cities, Molson Coors, Public Service Company of Colorado
Lower Clear Creek 2	6,453	4,395	10,848	City of Golden, City of Arvada, Standley Lake Cities
Lower Clear Creek 3	15,108		15,108	City of Golden, City of Arvada, Standley Lake Cities
Lower Turkey Creek	3,437		3,437	Denver Water
Mad Creek	2,564		2,564	Town of Empire
Mill Creek	3,628		3,628	Mill Creek Park WIA
Miners Gulch	1,000		1,000	City of Central City
Missouri Creek Res	2,438		2,438	City of Black Hawk
North Clear Creek	9,326		9,326	City of Black Hawk
North Turkey Creek	2,654		2,654	Conifer High School
Pecks Gulch	499		499	City of Central City
Quartz Valley Res	2,408		2,408	City of Black Hawk
Ralston Reservoir	6,844	9,391	16,235	City of Arvada, Denver Water, North Table Mtn W&S
Silver Plume	9,550		9,550	Town of Silver Plume
Singing River	6,148		6,148	Singing River Ranch
Soda Creek	8,425		8,425	City of Idaho Springs
South Clear Creek	7,862		7,862	Town of Georgetown
Urad Reservoirs	6,046		6,046	City of Golden
Total	**190,181**	**38,734**	**228,915**	

[3] Standley Lake Cities (SLC) includes the Cities of Northglenn, Thornton, and Westminster

RECOMMENDATIONS

This watershed assessment is a process that sets priorities, identifies stakeholders and ZoC. The next steps that are taken by stakeholders using the information presented in this report are essential to address the hazards identified through this process. Some potential opportunities are presented in the next section of this report. These recommendations are presented first to guide the reader through the Opportunities & Constraints section.

Stakeholder Group Organization

The ZoC are natural project areas for stakeholders to start the next planning steps. In some cases several ZoC may be lumped together to form larger project areas. Stakeholder groups will, by definition, include the water providers and/or municipalities that own water rights and operate in those watersheds, but should also include the following;

1. U.S. Forest Service - Clear Creek Ranger District of the Arapaho-Roosevelt National Forest.
2. Colorado State Forest Service - Golden District
3. Clear Creek, Gilpin and Jefferson Counties
4. Home owner associations
5. Ditch Companies and other water users, such as Molson Coors, Loveland Ski Area and Henderson Mine
6. Other interested groups such as power companies

Stakeholders should review the Opportunities & Constraints section below to determine what watersheds/ZoC should be their priority. Some additional planning will be required to initiate watershed protection/hazard reduction projects within those ZoC. The discussion below presents some of the suggested actions.

The existing Community Wildfire Protection Plans (CWPP) cover all portions of the watersheds/ZoC in the assessment area. Specific treatment areas and priorities identified in existing plans also should be reviewed for their contribution to the watershed protection efforts and incorporated into planning. All three counties that are part of this assessment area (Clear Creek, Gilpin and Jefferson County) have approved CWPPs. Other efforts, such as source water protection plans, may also provide some efficiency and consistency by incorporating the results of this assessment.

National Environmental Policy Act (NEPA) planning efforts on federal lands may be able to be modified to incorporate watershed priorities. The NEPA analysis and decision-making process may also benefit from the technical support provided by this watershed assessment. Other existing land and vegetation management plans, fuels treatment plans, source water protection plans, watershed restoration plans or prescribed fire or fire-use plans may exist that cover portions of the critical watersheds.

Wildfire Hazard Reduction Planning and Actions

Large wildfires have burned in the watersheds to the north and south of the Clear/Bear Creek assessment area. The current forest conditions in the assessment area are not substantially different from areas that have burned in recent wildfires. Therefore, it is recommended that water supply agencies plan for wildfires in their watershed(s). Planning for future wildfires now is prudent because actions following wildfires are emergency actions and there is little time to determine the best actions. Wildfire hazard reduction or watershed protection actions are logically different before a wildfire than after one, although there are some common components. Therefore, this section is divided into pre- and post-fire actions.

Pre-Fire Actions

The suggested actions before wildfire are;

1. Complete small-scale analysis and planning within each ZoC to identify specific hazard areas that will be the priority for vegetation treatments before fire, or targeted mitigation efforts after fire. Planning should also include setting long-term watershed/forest management goals such as increasing forest diversity to minimizing impacts from wildfires, or future insect and disease outbreaks. This planning can also be used to provide valuable site-specific information to cooperating agencies on forest management projects or fire management plans in those areas. Small-scale targeting of high hazard areas also allows water supply agencies to justify investments in hazard reduction or watershed protection projects.

2. Reduce wildfire intensity and subsequent fire severity in critical locations within and adjacent to ZoC, where possible. Although there are other strategies that can be pursued, the reduction of wildfire severity is the goal for minimizing adverse hydrologic responses following intense wildfires. Wildfire severity is the effect that the fire has on the ground. Vegetative forest treatments can be effective in reducing the threat of crown fire (Graham et al. 1999). Treatments that reduce density and change the composition of forested stands would reduce the probability of crown fire, decrease severity, and enhance fire-suppression effectiveness and safety (Oucalt and Wade 1999, and Pollet and Omi 2002). In forested stands that have developed without regular disturbance, combinations of mechanical harvest/thinning and prescribed fire are the most effective technique for altering the fuels matrix (Graham et al. 2004).

3. There will likely be high hazard areas identified within ZoCs that may not be available for traditional vegetation treatments because they are economically or administratively inaccessible. Examples of

economic inaccessibility include areas that are far from existing roads where it would be very costly to build new roads to provide access, or areas that are so steep that removal of logs using ground-based yarding may not be economically feasible and helicopter yarding may be the only option. An example of an administrative limitation would be wilderness or roadless areas.

These areas should be evaluated to determine if less traditional approaches could be used to reduce hazards to water supply. These methods could include; hand treatments, prescribed fire, created openings, fuel breaks and aspen enhancement. These treatments might cost more per acre than mechanical treatments but if they are targeted in identified high hazard areas, the additional cost could provide substantial watershed protection compared to treatments in areas with fewer limitations.

4. Establish ongoing communications with key federal, state and local agencies that will be responsible for fire suppression and mitigation following fires.

5. Where forest treatments are not possible and/or water supplies are critical and at risk, complete pre-permitting of sediment control structures downstream from high hazard areas. Following the Hayman Fire in 2002, Denver Water installed a sediment control structure in Turkey Creek above Cheesman Reservoir. It took more than one year to get all approvals and permits in place to construct that structure. The highest sediment yield from wildfires is usually in the first 2-3 years. Most of the permitting work can be completed ahead of time, including finding locations, conceptual design and planning with the appropriate government agencies.

6. Work with federal and state agencies to plan for managing wildland fires in specific locations as a management tool that would allow wildfire to reduce wildland fuels under defined circumstances. The conditions would be monitored frequently to ensure that the fire stays within that management prescription or suppression efforts would be required.

Post-Fire Actions

The suggested actions during and following wildfire are;

1. During a wildfire, review the small-scale analysis completed pre-fire, to determine if the fire is burning or likely to burn intensely in high hazard areas. Use that assessment to guide suppression efforts to either let that area burn under current conditions or encourage maximum suppression efforts in high hazard areas.

2. Contact the appropriate agencies and request a spot on the Burned Area Emergency Rehabilitation (BAER) Team. Review the large-scale and small-scale hazard assessments and bring that information to the BAER Team meetings. Advocate for watershed protection measures during the determination of mitigation measures by the BAER Team.

3. Target fire mitigation in specific areas of high hazard to water supply. Use the small-scale hazard identification analysis and overlay the burn severity mapping to determine high priority areas.

4. Mitigation measures will need to be determined on a site-specific basis. However, it is recommended that mitigation measures focus on effectiveness of treatment rather than cost per acre. Mitigation that targets fewer acres but with a higher effectiveness will likely be more successful. For example, wood shred mulch is much more effective on steep, high burn severity slopes than agricultural straw, but costs more. Targeting specific high hazard areas to be treated allows these more effective, more expensive treatments to provide higher levels of watershed protection, sometimes at the same cost.

5. Consider additional mitigation measures in high hazard areas. These could include; grade control structures high in watersheds to minimize gully head-cutting, felling of dead trees into small channels to provide roughness, and hand application of wood shred or wood straw mulch.

6. Review plans for sediment control structures and determine if they should be taken through the final stages of permitting and installed. Although these structures are expensive, the effects from fire may be even more expensive. Several water agencies with recent experience in Colorado have estimated that it is 10-20 times more expensive to remove sediment from a reservoir than the cost of these temporary structures.

OPPORTUNITIES & CONSTRAINTS

This section of the assessment presents the first step in identifying opportunities and constraints within the ZoC. This analysis is intended to identify potential opportunities that will aid the stakeholders in deciding whether to pursue watershed protection/hazard reduction efforts, the overall scope of those efforts, and identification of the key partners for those projects. This section is organized by general descriptions of the opportunities and constraints first and then presentation of potential opportunities for each ZoC that are shown on Figure 14.

General Opportunities & Constraints

The opportunities and constraints described below were applied to the ZoC as a series of filters and identifiers of potential opportunities.

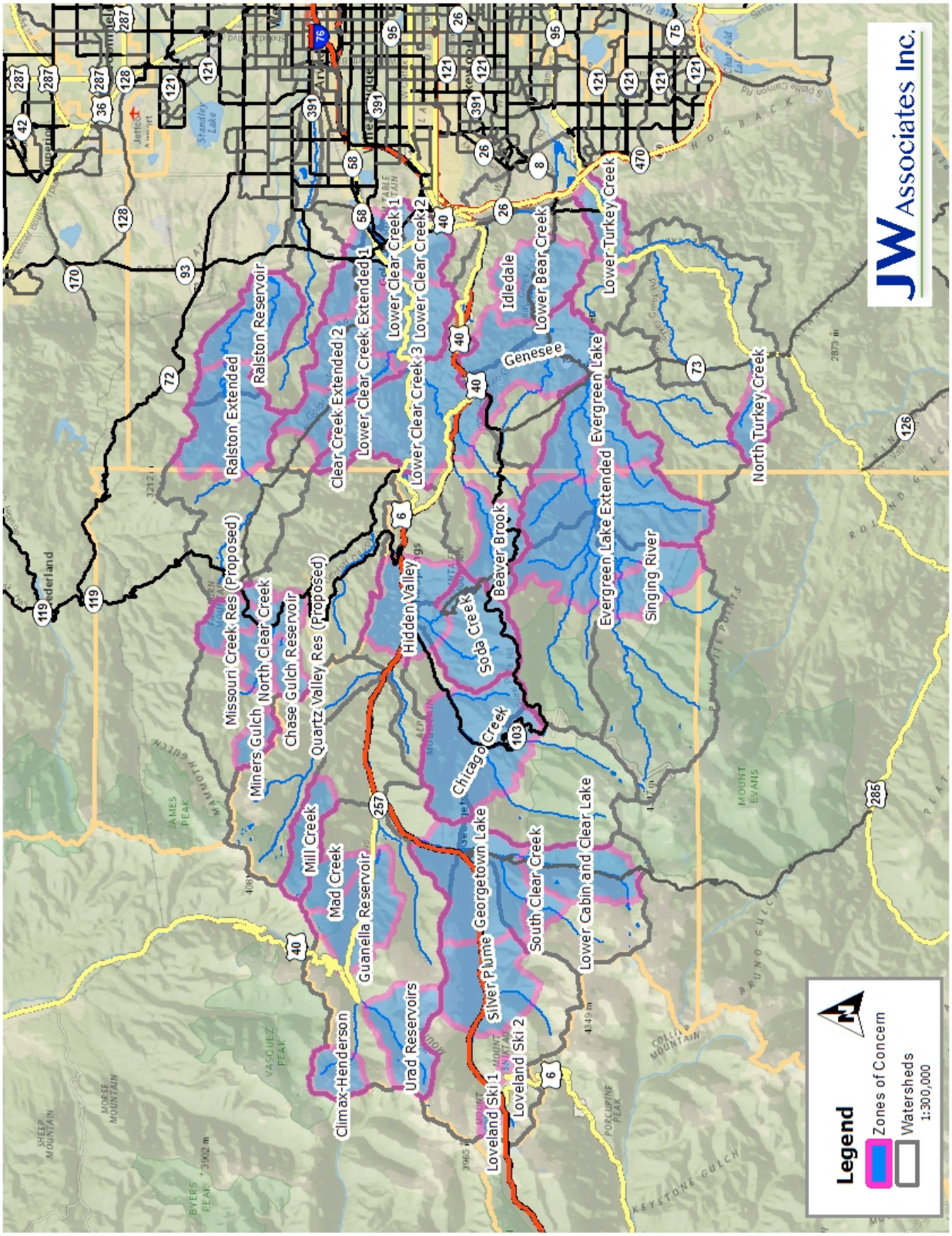


Figure 14. Clear/Bear Creek ZoC Base Map

Ownership

Major ownership classifications are Federal, State, Local Government and Private. Federal Lands include the National Forest System Lands, Bureau of Land Management (BLM), National Park Service, Department of Defense, and potentially other agencies and departments. State lands are typically those owned or managed by the State Land Board, the Colorado Division of Wildlife, or State Parks. However, there are other agencies or institutions, such as state universities, that may also own significant acreage.

Local Government lands typically include county, city or town-owned properties. County-owned lands are often managed as open space or park lands. City-owned lands are also often owned and managed for open space or parks, but also for watershed protection or other purposes.

The final category, Private Lands, is a catch-all that can include a myriad of other types of ownerships including special district lands, company or corporate-owned lands, privately-owned properties and more. These, too, can be of all sizes. Privately-owned parcels can form an extremely complex ownership pattern, particularly where they are comprised of old mining claims.

Access

Access to and within a watershed or ZoC is a key factor in determining opportunities for mitigating wildfire hazards or the ability to install, operate and maintain erosion and sediment control structures following wildfires. The analysis often is limited by the data available in determining what roads exist within any given area. Normally, data layers available for the analysis show major roads and access routes, but often fail to include small, local roads and trails, particularly on non-federal lands. Such roads are very important for accessing backcountry areas for conducting mitigation activities. Experience has shown that old roads used for mining or logging that can be temporarily re-opened to conduct project work may not be shown on any maps. Another option is temporary roads that can be constructed and closed following treatment, but they add costs to projects and current policies on many federal lands make even use of temporary roads difficult.

When conducting traditional logging and thinning operations where products are removed from the forest, areas within ¼ to as much as ½ mile of roads can be considered. Specialized logging equipment commonly referred to as "forwarders" can be used to move logs and other products to the roadside from as far as 2 miles or more if terrain allows. If products do not have to be removed to meet fuel loading requirements and alternate treatment methods such as "mastication" or mulching can be used, equipment can be "walked" to treatment units as far from roads as terrain allows and it is practical to maintain and support the equipment.

Slopes

Land slope can be a major constraint when considering where and what treatments may be conducted to reduce wildfire hazards. Slope constraints are related directly to the typical harvesting or treatment systems and equipment employed and available within Colorado. Land management agency policies may also constrain the slopes upon which treatments may be conducted.

Slopes of 30 percent or less are the easiest to treat and the most traditional threshold for treatment given typical harvesting systems and equipment availability. Technological, power and other improvements now allow equipment to operate on slopes of 40 percent or perhaps even steeper ground. Experimental work conducted by the Colorado State Forest Service on Denver Water's lands in the Upper South Platte showed that tracked mastication equipment could work on slopes of up to 55 percent without causing erosion.

Quite recently in Colorado there have been several cable logging and even a few helicopter logging operations conducted. Slope is typically not an absolute constraint with these types of operations, but other factors such as the shape of the hillside (convex vs. concave), whether the project can be treated from above or below and others determine actual project feasibility.

The stakeholders decided to use a 40 percent slope as the upper limit of mechanical treatments. Potential opportunities were identified as greater on shallower slopes (less than 40 percent slope).

Wilderness Areas

Operations in designated Wilderness Areas are highly restricted by law and agency policies. Often the only treatments possible would be to plan for use of natural fire to reduce wildfire hazards. The wilderness areas and roadless areas in the assessment area are shown on Figure 15. There are two wilderness areas, Mount Evans and James Peak, in the assessment area.

Roadless Areas

Operations in designated Roadless Areas are restricted primarily by agency policies. Regulations allow construction of temporary roads, and their closure upon project completion, for the purpose of conducting harvests and wildfire hazard reduction treatments. Agency policy has caused treatments to focus on areas other than roadless whenever possible.

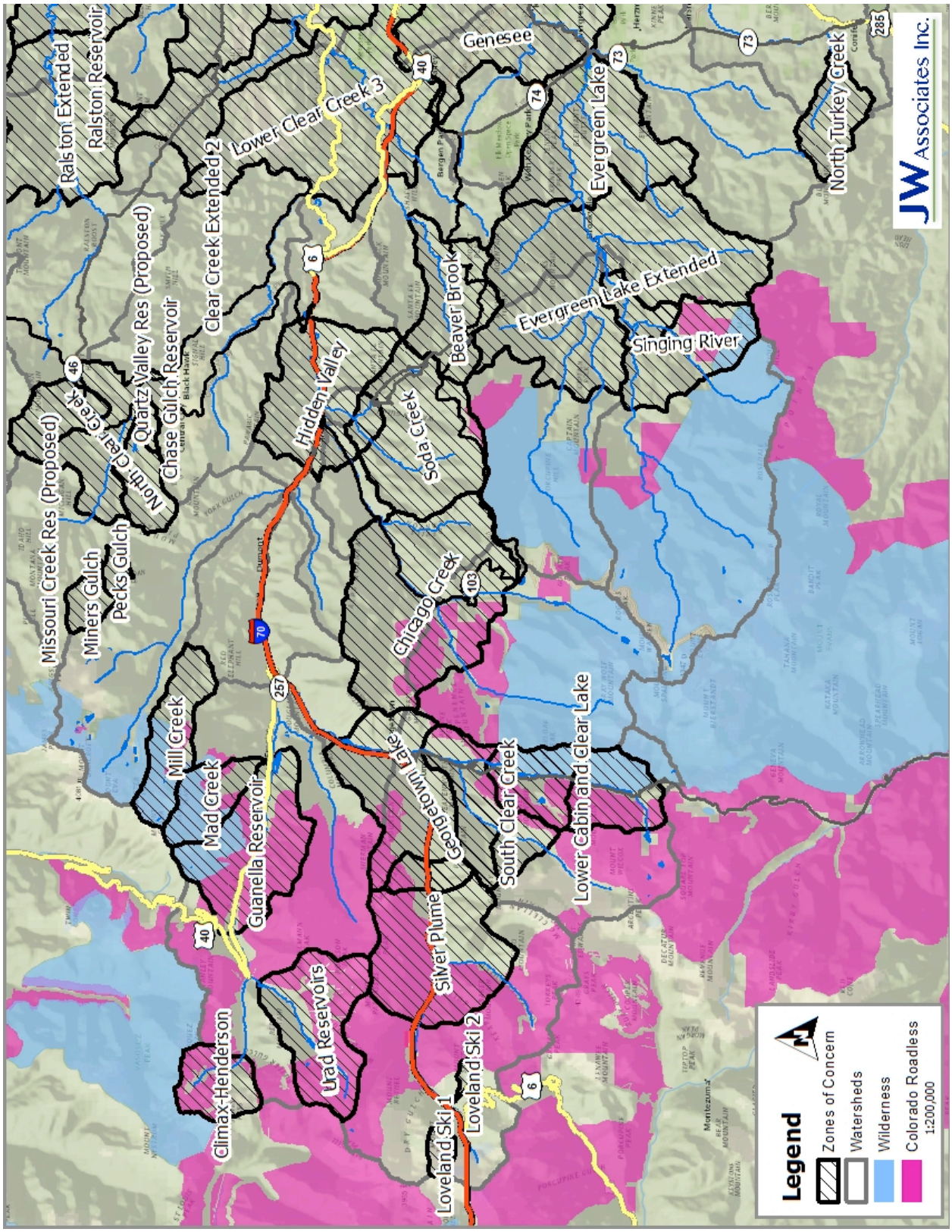


Figure 15. Wilderness and Roadless Areas in the Clear/Bear Creek Assessment Area

Colorado has developed rules for treatments within federal Roadless Areas. The Colorado Roadless Areas have been reviewed and adjusted for actual conditions. Treatments within Colorado Roadless Areas may be possible adjacent to at risk communities and for reducing wildfire hazards within watersheds. Areas within ½-mile of communities, and in some circumstances up to 1.5-miles from communities, may be treated to reduce wildfire hazards. Areas within watersheds may be treated if the USFS Regional Forester determines a significant risk of wildfire exists. All decisions about specific projects within Roadless Areas will be made by the US Forest Service.

The Colorado Roadless Areas include some area that are designated as Upper Tier areas that further restricted activities allowed. The Upper Tier designation does not allow tree cutting and temporary road building for watershed protection. These Upper Tier areas are displayed on the maps for each ZoC below. The wilderness areas and roadless areas in the assessment area are shown on Figure 15. There are many roadless areas in the assessment area, many are associated with adjacent wilderness areas.

Vegetation

Vegetation is what fuels a wildfire. The vegetation type and its arrangement, size, density, and moisture content; the slope of ground and the aspect it is found on; whether it is dead or alive; the weather and season of the year, and more all dictate if and how intensely that fuel will burn.

The Colorado State Forest Service is developing a series of documents related to watersheds and their protection. The first document, tentatively titled, "*A Comprehensive Strategy for the Management and protection of Colorado's Watersheds,*" will have a series of companion documents entitled, "*Management and Protection Techniques for Colorado's Watersheds*." The first companion document discusses management of ponderosa and lodgepole pines and uses numerous photographs to illustrate what these treatments might look like. Additional species will be added to this series over time.

Lower elevation ponderosa pine stands are a major concern in the Clear/Bear Creek assessment area because this forest type is the one considered most "out of whack" from an ecological perspective. It is the forest type

that has received the greatest impacts from human use and settlement and has the greatest departure from its historical conditions. These factors have contributed to conditions that make it very conducive to large, intense and damaging wildfires. Indeed, some of Colorado's most damaging fires, from a watershed perspective, have burned in this forest type. This phenomenon first came to the attention of water providers and land managers following the 1996 Buffalo Creek Fire in Jefferson County. Treatments that return and emphasize characteristics of pre-settlement ponderosa pine stands may provide the best opportunity to improve forest sustainability in this forest type. (See *Forest Restoration Guidelines for Front Range Ponderosa Pine*, Colorado State Forest Service.)

For the Clear/Bear Creek assessment area the stakeholders also decided to use lodgepole pine and spruce/fir at higher elevations as targets for vegetation treatments to reduce wildfire severity. Aspen was also added to the Opportunity maps.

Lower elevation ponderosa pine stands are a major concern because they are considered most "out of whack" ecologically

Aspen is an aggressive invader to disturbed areas. It quickly populates areas damaged by fire, rockslides or mass soil movement, avalanche paths and run-out areas, large areas of windthrow, and other areas where conifers have been killed. It is normally a successional species in that as it matures, more shade tolerant conifer species begin to grow and alter the forest type. In some areas, however, aspen can be a climax species.

Aspen is somewhat "resistant" to fire as crown fires will seldom carry through this forest type except under extreme drought combined with windy conditions. Its susceptibility to fire is usually seasonal: normally only burning during dry fall periods, often after their leaves have fallen; and, occasionally, in the spring, prior to green-up if conditions are dry. Because of these characteristics, it is a good species to maintain or promote within the landscape. This can be done using a variety of silvicultural and prescribed fire techniques.

Spruce/fir is a major component of the forest vegetation in the Clear/Bear Creek Watershed. This forest type is comprised of mixtures of Engelmann and Colorado blue spruce, subalpine fir and other minor species. It is a forest type that, under natural conditions, has a very long fire interval – perhaps as long as 500 to 700 years. When it does burn, it burns very intensely and can cause severe erosion and sedimentation problems. Human-caused fires are a wildcard that can occur anytime weather conditions allow, introducing an unnatural fire event into that normally long historic fire interval.

Spruce/fir is difficult, within a short time period, to thin sufficiently to develop diversity significant enough to reduce wildfire hazards. This much needed diversity must be developed by creating varied conditions at the stand and landscape levels by group selection, small patch cutting, creating permanent openings, converting areas to aspen, and by other techniques. Once management has begun for watershed protection, in some situations it, too, may be advisable to utilize less traditional management techniques for long-term

management. Less traditional techniques may include; thinning, group selection, patch cuts and small clearcuts to break up crown density.

In Colorado, lodgepole pine is also found in dense, continuous stands. Lodgepole pine normally comes in after a fire. It often can be considered the climax species under normal fire intervals. In the absence of fire lodgepole stands will transition to more shade tolerant species. Lodgepole pine has a natural fire interval that may begin at about 150 years of age up to perhaps 300 years. Mature stands begin to "fall apart" due to insect, disease, rot and other factors. As trees fall, they add significant heavy fuel to the forest floor, and helping to create conditions that make the species susceptible to hot, fast-moving crown fires. It too, like the spruce/fir, is difficult within a short time period, to thin lodgepole pine sufficiently to develop diversity significant enough to reduce wildfire hazards. Diversity must be developed by creating diversity at the stand and landscape levels by clearcutting, patch cutting, creating permanent openings, or converting areas to aspen. Once management has begun for watershed protection, in some situations it may be advisable to utilize less traditional management techniques for long-term management (Lodgepole Pine Management Guidelines for Land Managers in the Wildland -Urban Interface, Colorado State Forest Service, 2009). Less traditional techniques may include; thinning, group selection, patch cuts and small clearcuts to break up crown density.

Mountain pine beetles (MPB) have and are impacting to varying degrees the lodgepole pine forests in portions of the Clear/Bear Creek study area. Those forests that have not yet been impacted by the current MPB epidemic continue to be at risk for attack and the extensive mortality seen elsewhere in Colorado.

Potential Effects of Fire in Mountain Pine Beetle-Impacted Areas

The lodgepole forest is a disturbance-driven and fire-dependent forest type. The risk of fire is present through much of this forest's life cycle. The degree of increased risk due to the epidemic has been a matter of academic debate. Regardless of this debate over the probability of such fire, it is important for watershed stakeholders to understand how such fires might burn and what the impacts to forest soils and watersheds might be. Recent reports from Canada about fire behavior in beetle impacted stands, and experience with several small-scale fires in Colorado, provide insight into what we might experience in Colorado (JEM 2008, Page and Jenkins 2007, Colorado State Forest Service 2009, and Schroeder and Mooney 2009).

The Red Needle Stage (within three years of infestation):

1. Relatively benign ground fires may transition into independent crown fires without a torching phase. In Canada, thresholds for such fires were 80 degrees and 30 percent relative humidity. Both red and yellow tree crowns readily carried fire with little wind or slope. Initial attack efforts fail even under milder fire danger indices.

    a. Good anchor points, escape routes and safety zones are essential.

    b. During fire incidents, constantly monitor escape route conditions.

2. For the three years following the epidemic, each fire season started earlier than the last. Major project fires might occur within weeks of snow-free ground.

    a. Spotting from tree crown to tree crown without any supporting ground fire may occur.

    b. Multiple-mile runs may be common even with relatively mild winds.

    c. Fire spread direction may become fickle, changing with very subtle wind shifts. These shifts are difficult for firefighters to detect at ground level inside timber stands.

3. Think on a landscape scale when developing suppression tactics for individual fires and when planning for fuels treatments and wildfire hazard mitigation.

    a. Multiple lightning starts may burn into one another by the end of the first or second burning periods.

    b. Deciding where to make a stand can become a complicated exercise in predicting fire dynamics and time frames.

    c. Fire activity as described above may occur in areas with continuous crowns of red or yellow needles. Fires may behave like an elevated grass Fuel Model 1, often as an independent crown fire.

    d. Fire behavior may force firefighters to back off and give up country to find more secure fire control features. Plan multiple fuelbreaks and other "defensive" treatments across the planning area.

    e. Clearcuts (with or without slash disposal), meadows, and open fuelbreaks likely will be the preferable location for fire control activities because in such areas the fire is more likely to stay on the ground where firefighters can deal with it.

The Grey Stage (after most needles drop in the impacted stands)

1. Once needles drop from trees, fire behavior is expected to become much more subdued and predictable. The increase in the amount of available dead fuels will result in slower moving but more intense fires that resist control and are more likely to damage forest soils.

2. Snag hazards to firefighters, forest visitors and landowners greatly increase over time during the grey stage. In Canada, mechanized equipment and access are available for much of its initial fire attack and suppression work. In many parts of Colorado, access is limited and mechanized equipment may not be available.

The Down-and-Dead Stage (as trees fall over time)

1. As trees rot and fall or are blown over, heavy fuels accumulate on the ground. Hot surface fires with high resistance to control can be anticipated that will damage forest soils.

2. Fuel profiles will become increasingly complex as new lodgepole seedlings and saplings become established in this dead fall. It is not difficult to visualize a fuel profile of continuous heavy dead-down material with large patches of interlaced crowns twelve to fifteen feet tall.

The British Columbia experience with fire behavior reminds us that we need to become vigilant observers in our own insect damaged stands. While we may not be exposed to exactly the same behavior they are experiencing, we most certainly will see things out of the "norm" for Colorado. The red needle stage is obviously hazardous and of relatively short duration. The standing dead trees present special hazards for falling snags. The accumulating dead-down has high fire intensity during the early stages and creates challenges for fire line construction and firefighter access. Future dense lodgepole stands with heavy dead-down material on the ground may become the most problematic from both a soil erosion and fire suppression perspective.

Mountain Pine Beetle Summary Points & Implications:

1. The current mountain pine beetle infestation is unprecedented in Colorado's recorded history. Our expectations of what will happen when fire occurs in these areas are based on information from beetle outbreaks in other areas, the science of fire ecology, and on fire behavior predictions.

2. During the "red needle stage" when red/brown-colored pine needles are still attached to the trees, the needles contain volatile chemicals that increase flammability. The red-needle stage generally lasts between three and five years.

3. The beetle epidemic will increase fire danger, though not as dramatically as some experts are predicting. In beetle-infested areas, fire hazard will become elevated more quickly during shorter time periods when conditions are dry than it will where pre-epidemic conditions exist.

4. Although the proper alignment of environmental factors (fuels, topography, winds, temperature and relative humidity) are still necessary to create conditions that will drive fire in lodgepole pine, experience indicates that such an alignment can occur within a shorter timeframe because of the epidemic.

5. When significant quantities of trees begin to fall, the jackstraw effect will suspend logs above the surface of the ground. On average, these logs will be drier than logs that are in direct contact with the ground surface and may more easily ignite.

6. The lack of forest shading resulting from downed trees will cause an increase in surface temperature. The combined increase in temperatures and decreased moisture content may increase the probability of ignitions from both human and natural causes.

7. Fires that burn in jackstraw logs will occur as slow-moving, high-intensity fires that will be difficult to control. These fires will kill lodgepole pine seedlings and saplings, and cause major damage to forest soils. Erosion, sedimentation, and mudslides or debris flows may be major consequences after these fires. If the trees are too young to produce cones or have non-serotinous cones when burned, such areas likely will not regenerate and will remain as openings for long periods of time.

8. The greatest threat to firefighter safety will likely be from falling dead trees (snags) that will occur during fire events, rather than from fire spread.

9. Over time, the numbers of dead trees that will have fallen will greatly increase. In addition, as fires burn through decomposing root systems, the number of snags that fall will substantially increase during the fire. These jackstraw logs will make walking difficult in and around fires, which will make it even more challenging to escape falling snags.

10. To improve firefighter safety, it may be advisable to increase the use of heavy equipment, such as bulldozers, whenever and wherever possible. Understand however, that use of such equipment will likely require additional post-fire rehabilitation to avoid adding to the erosion and sedimentation potential.

11. The potentially damaging effects to communities, watersheds and infrastructure (power lines, recreation sites, roads, reservoirs, etc.) from larger wildfires in beetle-infested stands of lodgepole pine will increase and remain high even after some regeneration has occurred. (Such behavior was observed in the 1980 Emerald Lake Fire, which burned in jackstraw that resulted from the 1950s spruce beetle epidemic.)

12. Individuals and groups need to be proactive in their efforts to reduce hazards from falling snags and wildfire around homes, businesses, utilities, infrastructure, and other high-value assets. Such work must occur before wildfire incidents.

Loveland Ski Area ZoC

This section addresses the far western and highest elevation portion of the assessment area. The Loveland Ski Area has two diversions located near Loveland Pass. The Loveland Ski 1 and 2 ZoC are discussed together in this section because they are close to each other (Figure 16). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

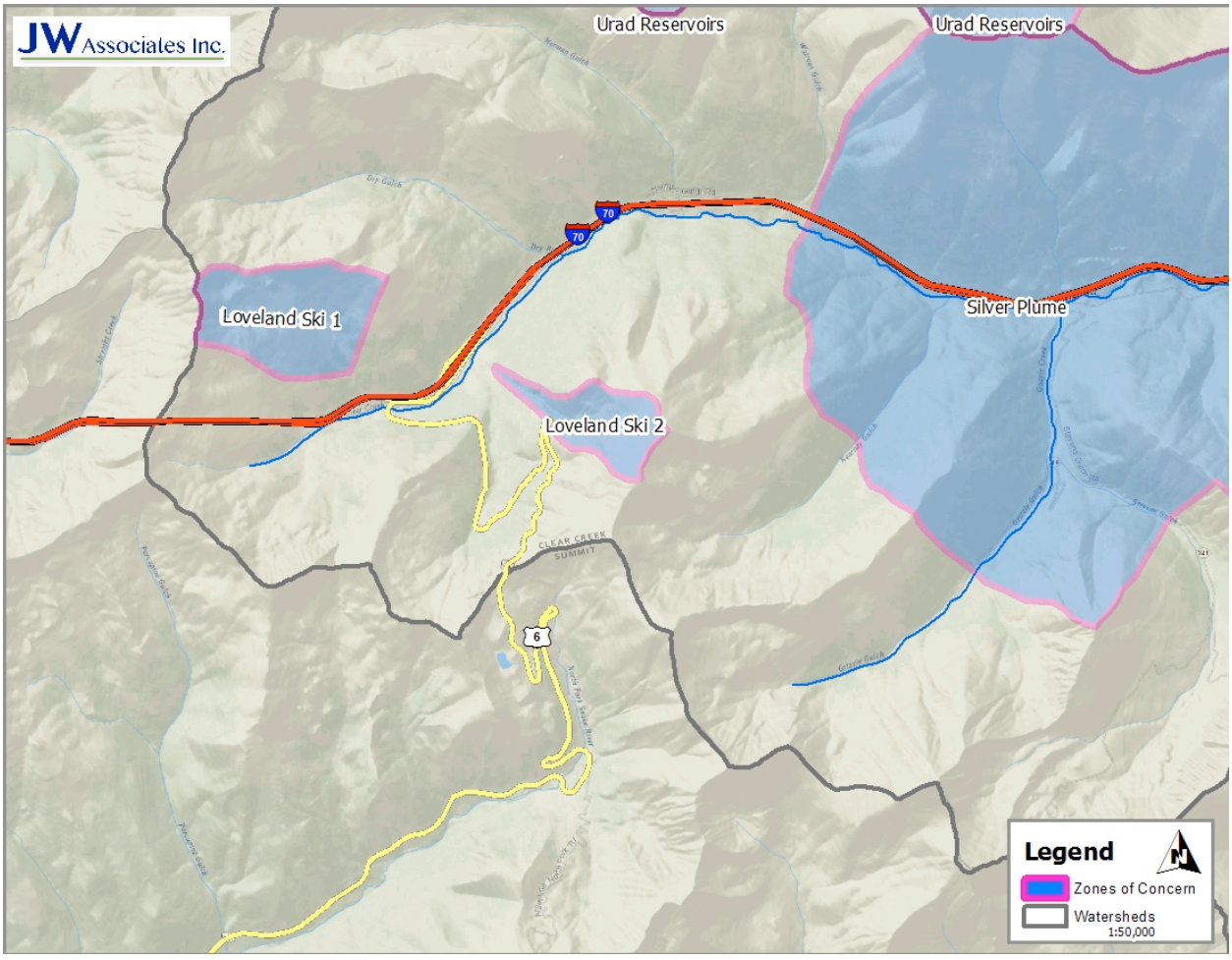


Figure 16. Loveland Ski Area ZoC Location

Loveland Ski Area Ownership

Loveland Ski 1 and 2 ZoC are entirely on National Forest System (NFS) lands (Figure 17).

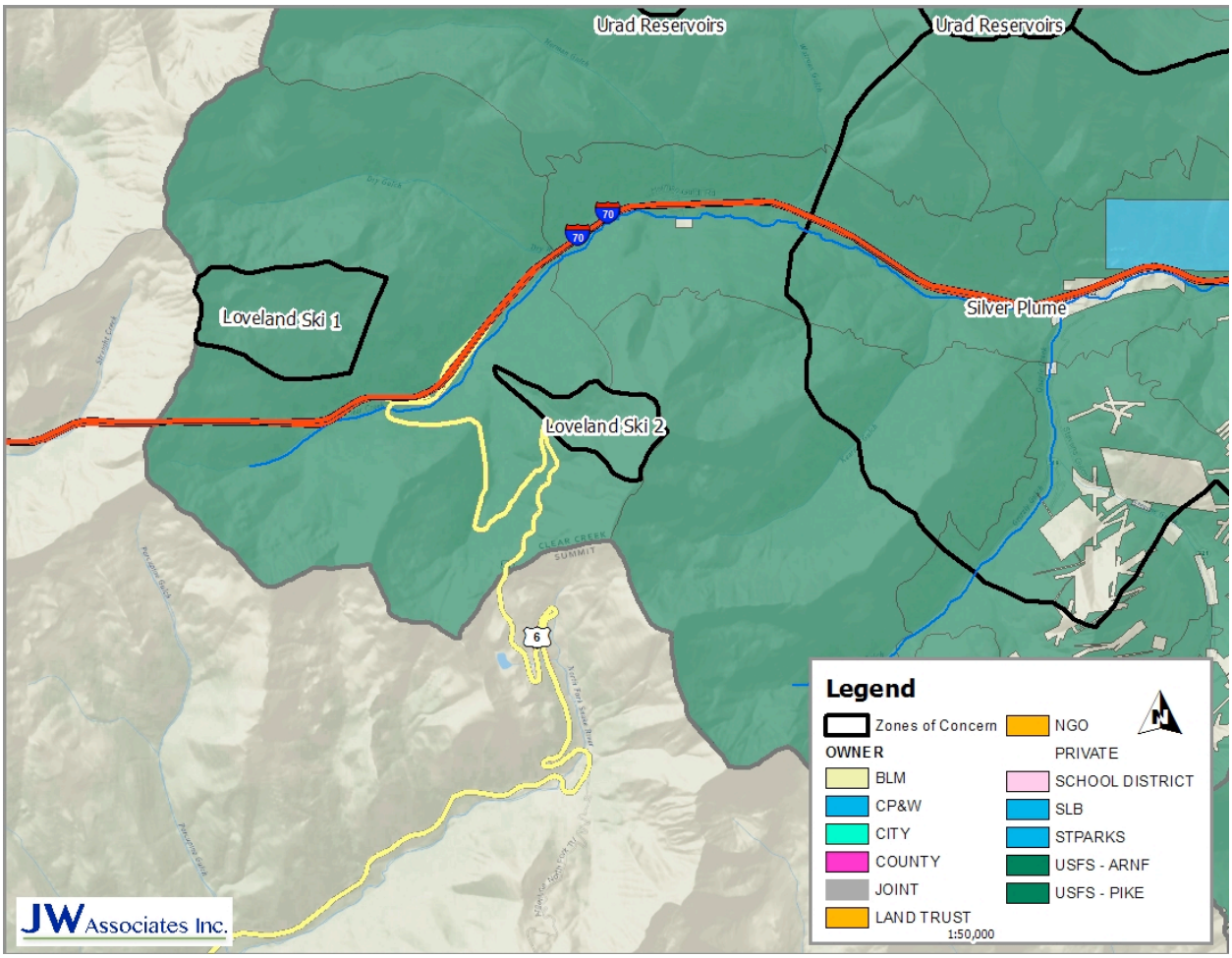


Figure 17. Loveland Ski Area ZoC Ownership

Loveland Ski Area Watershed Priority

The Headwaters Clear Creek watershed is ranked as Blue (Category 2) overall. It is also ranked as Orange (Category 4) for Soil Erodibility.

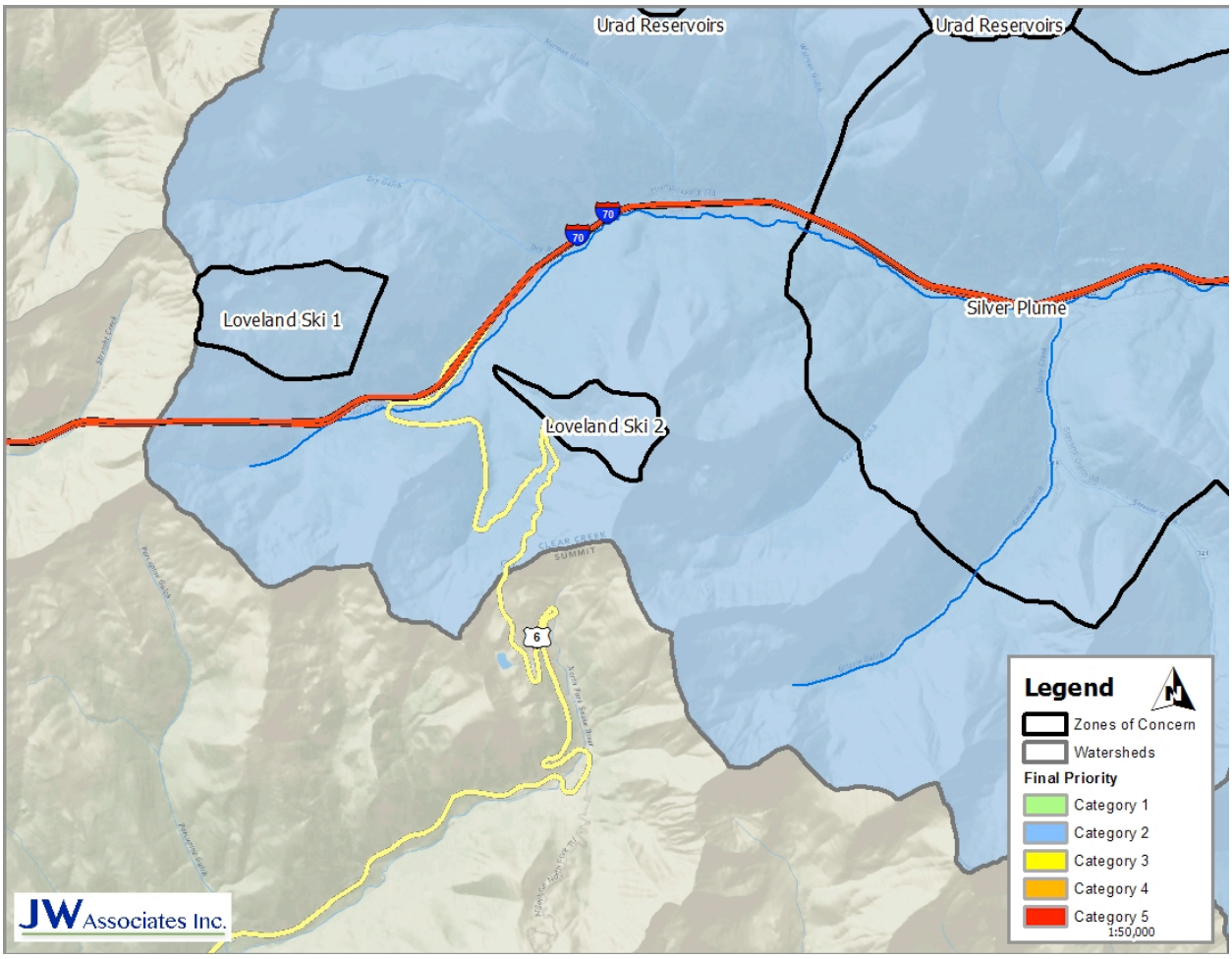


Figure 18. Loveland Ski Area ZoC Watershed Priority

Loveland Ski Area Slopes

The Loveland Ski 1 ZoC has mostly shallow slopes with some steep slopes in the northern and western portions (Figure 18). The Loveland Ski 2 ZoC has mostly steep slopes with a band of shallower slopes in the northern portion.

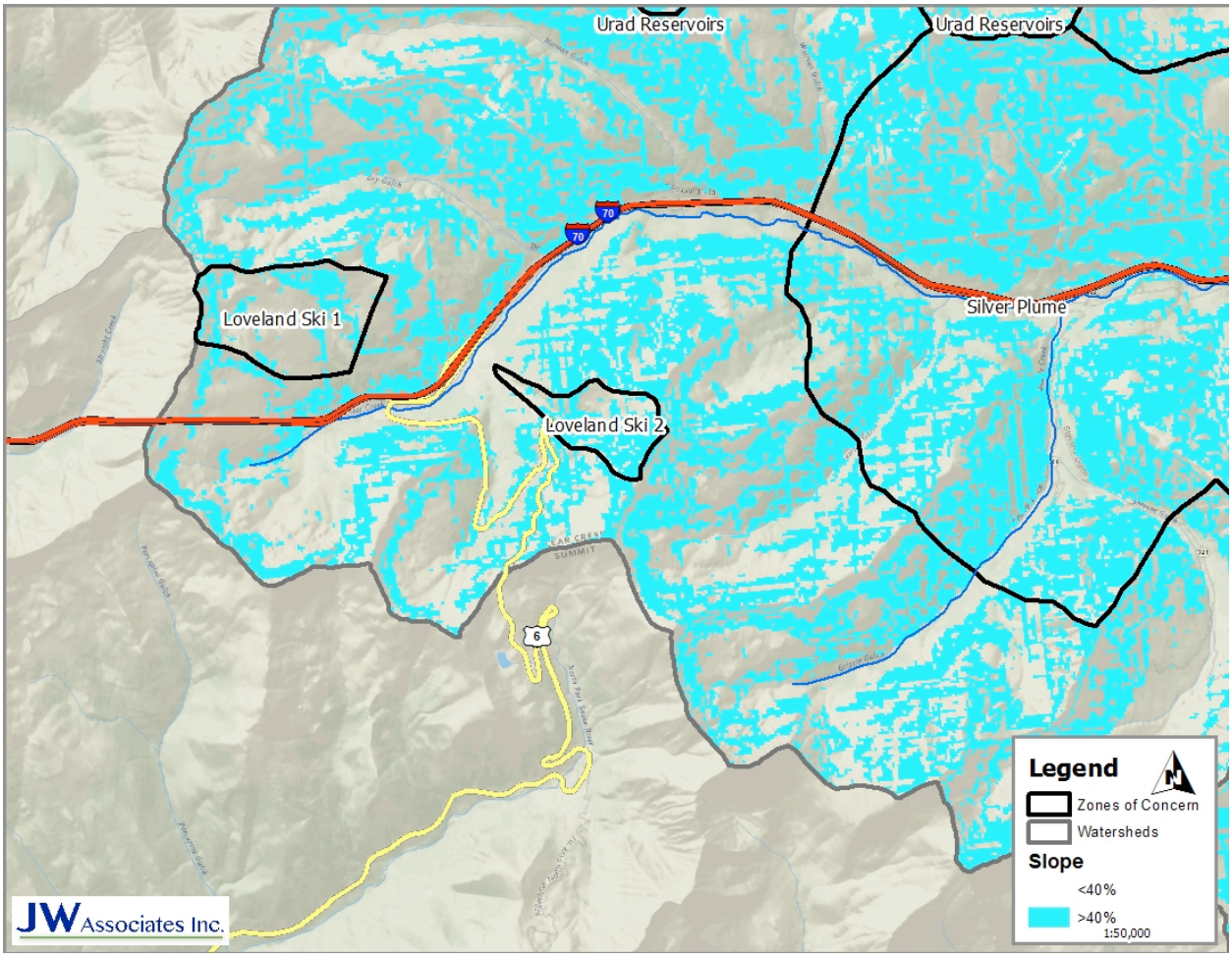


Figure 18. Loveland Ski Area ZoC Slopes

Loveland Ski Area Special Areas (Wilderness/Roadless)

Neither of these ZoC contain any wilderness or roadless areas (Figure 20). However, the Mount Sniktau Roadless Area boarders the Loveland Ski 2 ZoC to the east.

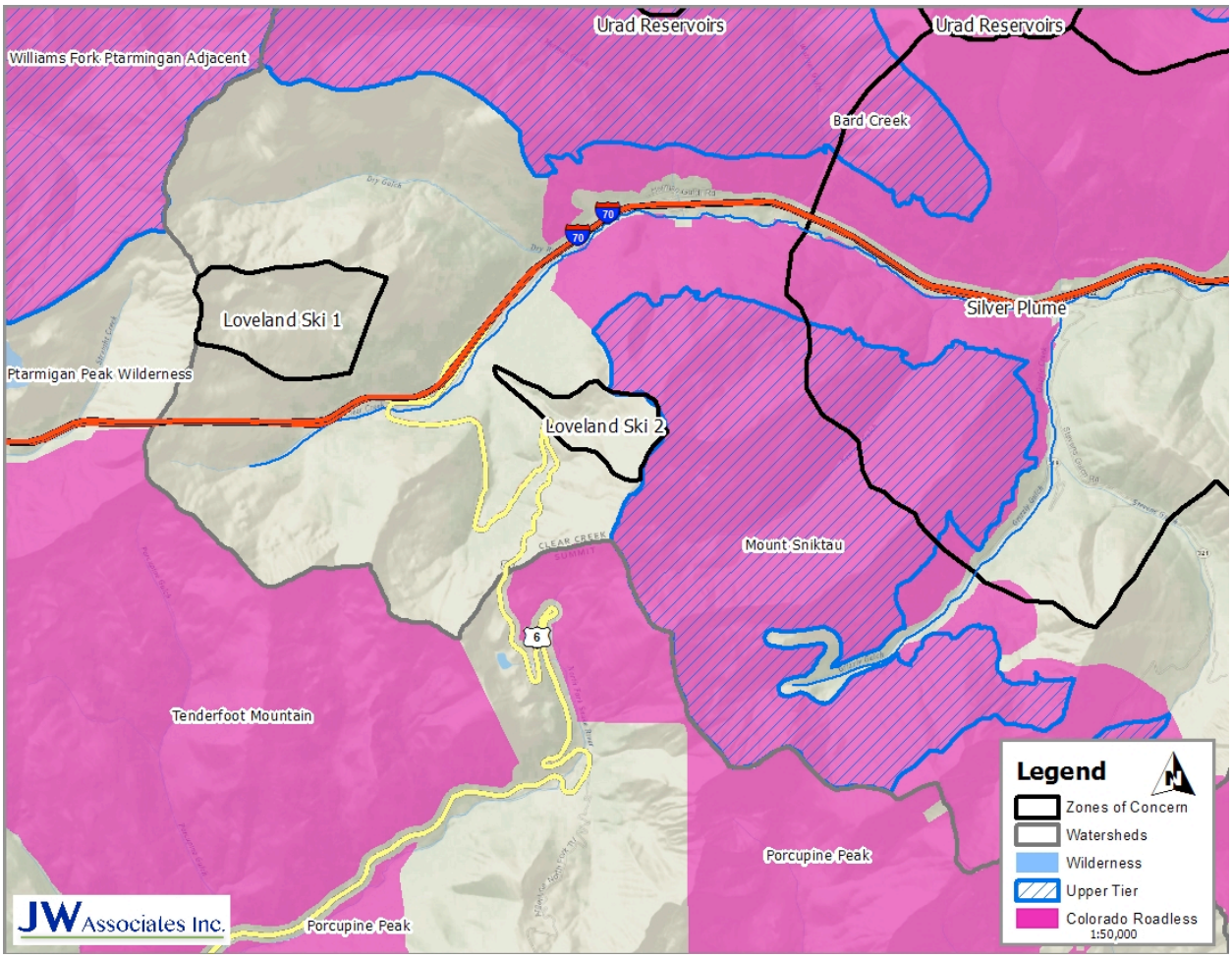


Figure 20. Loveland Ski Area ZoC Special Areas

Loveland Ski Area Vegetation

The Loveland Ski 1 ZoC is mostly rock, snow and ice (Figure 21), however there is a small portion of the ZoC that contains spruce-fir. The Loveland Ski 2 ZoC s mostly alpine vegetation or rock, snow and ice, bit does contain a slightly larger area of spruce-fir than Loveland Ski 1 (Figure 21).

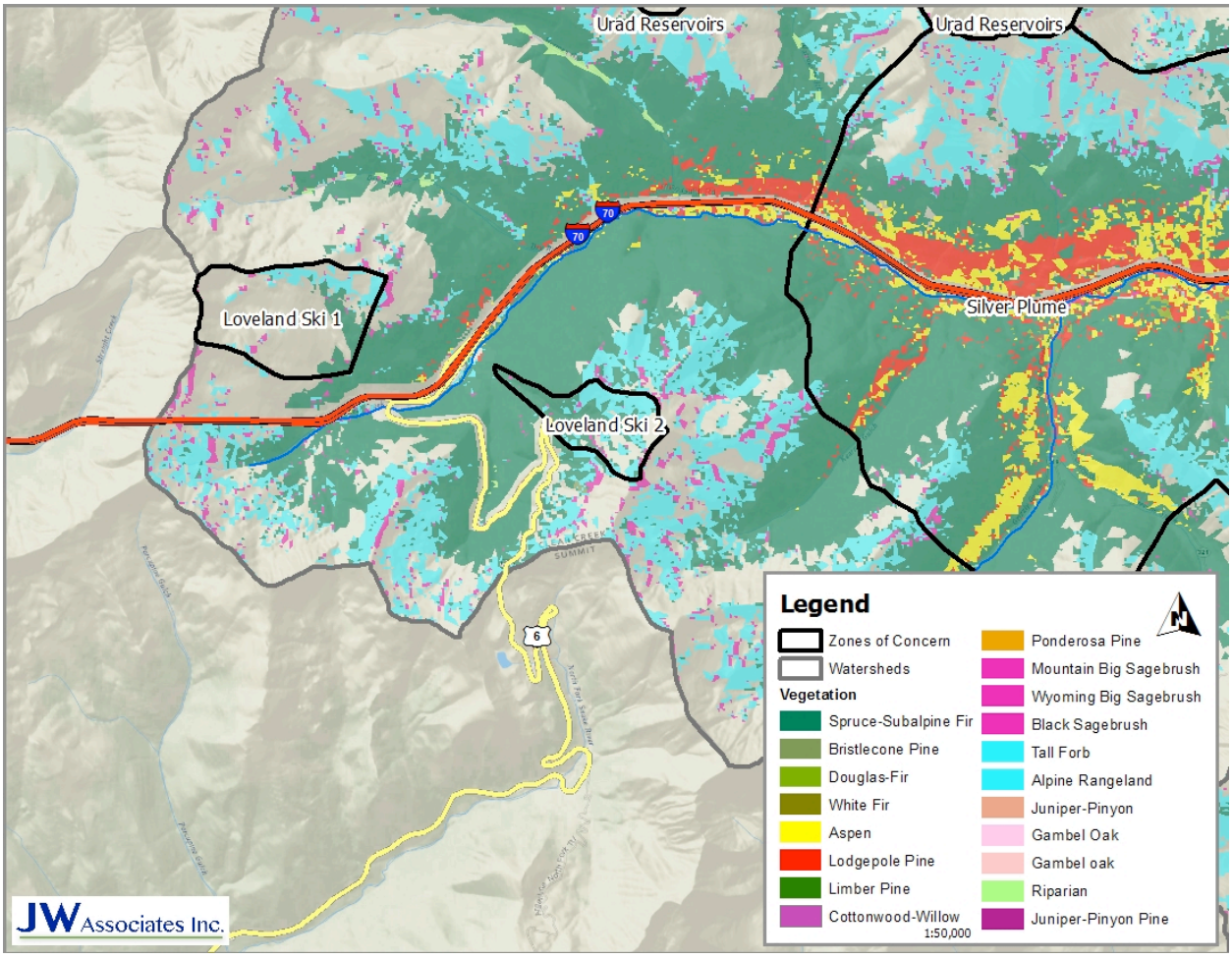


Figure 21. Loveland Ski Area ZoC Vegetation

Loveland Ski Area Access

Road access in these ZoC is very limited or nonexistent (Figure 22).

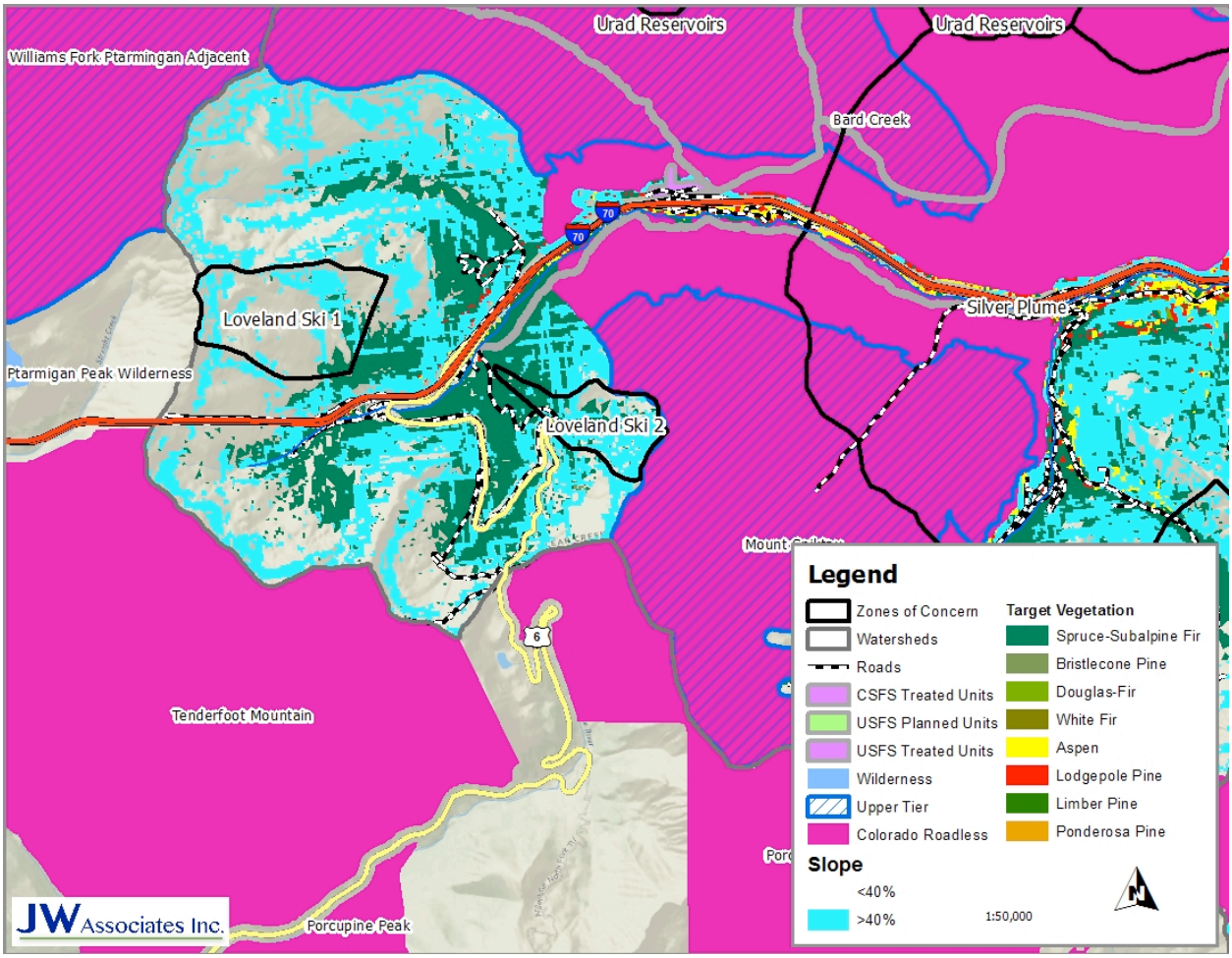


Figure 22. Loveland Ski Area ZoC Opportunities

Loveland Ski Area Opportunities

These ZoC contain small areas of forest vegetation therefore, few management opportunities exist. They are also both within the Loveland Ski Area, therefore vegetation management for recreation purposes may take precedence over watershed protection.

Upper West Fork Clear Creek ZoC

This section discusses the Climax-Henderson and Urad Reservoirs ZoC because they are adjacent or overlapping (Figure 23). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

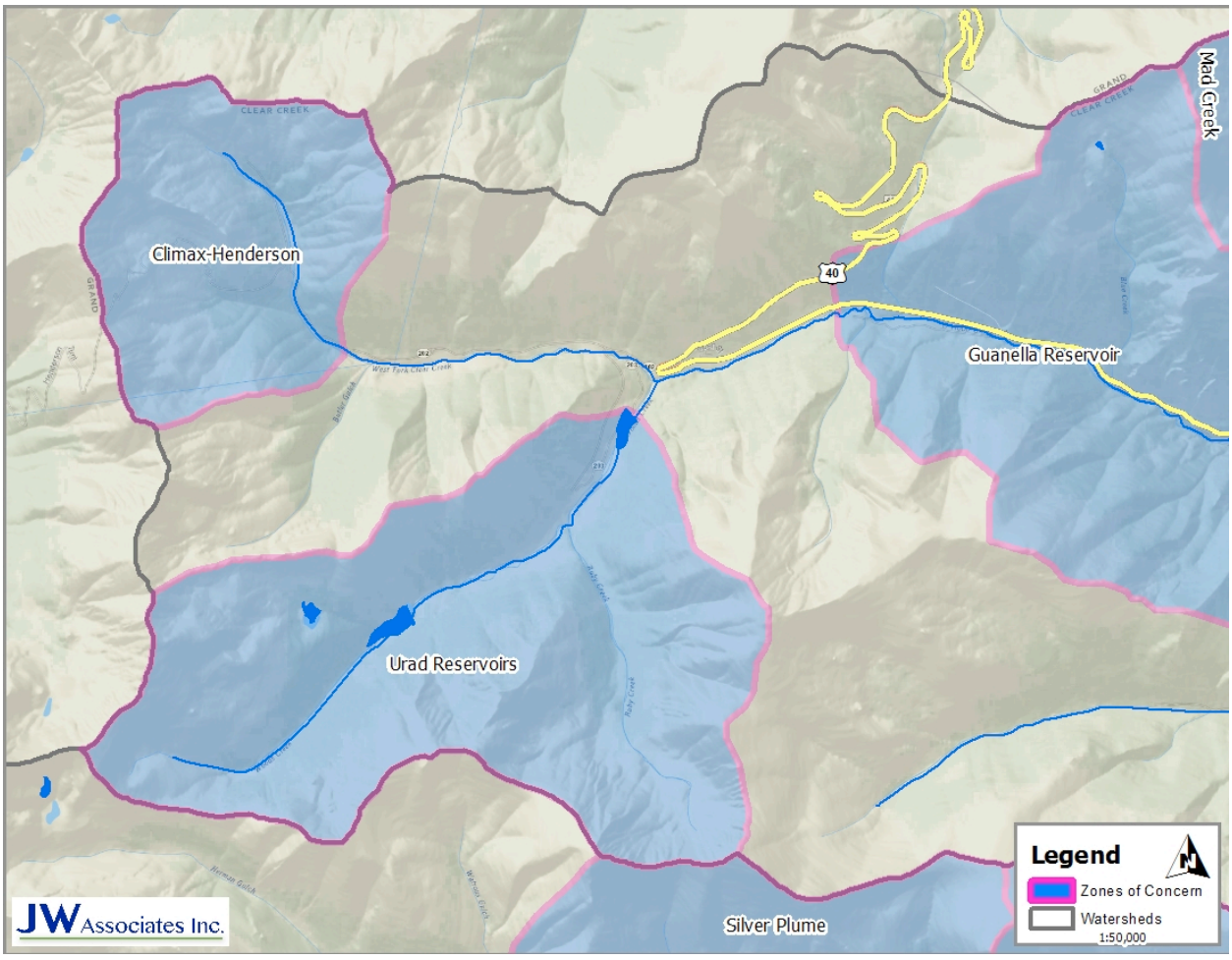


Figure 23. Upper West Fork Clear Creek ZoC Location

Upper West Fork Clear Creek Ownership

The Climax-Henderson ZoC is nearly all on NFS lands (Figure 24). The portions of the Urad Reservoirs ZoC around the reservoirs, surrounding Woods Creek and north of Woods Creek below Upper Urad Reservoir is private land. The remainder of the Urad Reservoirs ZoC is all NFS lands (Figure 24).

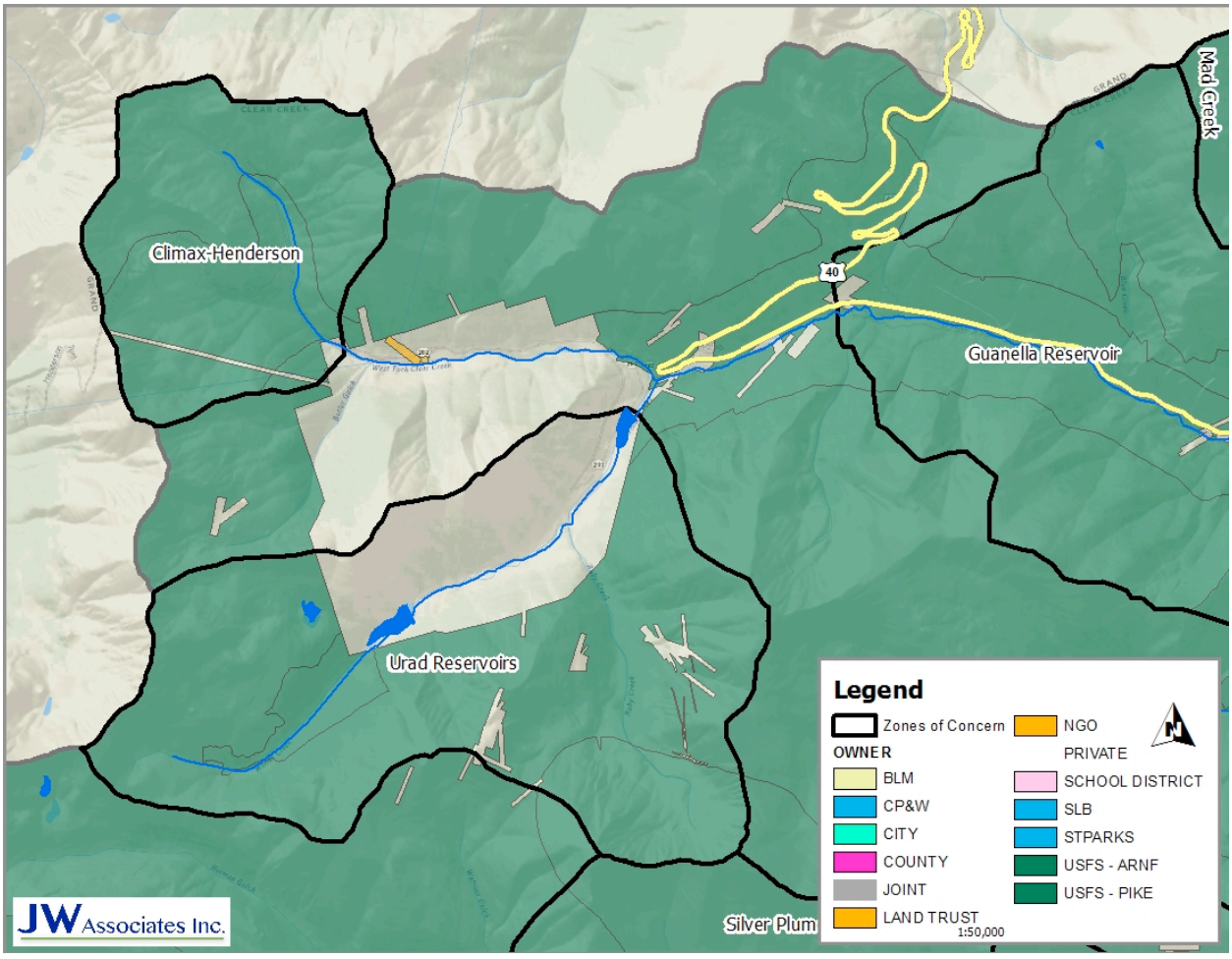


Figure 24. Upper West Fork Clear Creek ZoC Ownership

Upper West Fork Clear Creek Watershed Priority

The West Fork Clear Creek watershed is ranked as Blue (Category 2) overall (Figure 25). It is also ranked as Orange (Category 4) for Soil Erodibility.

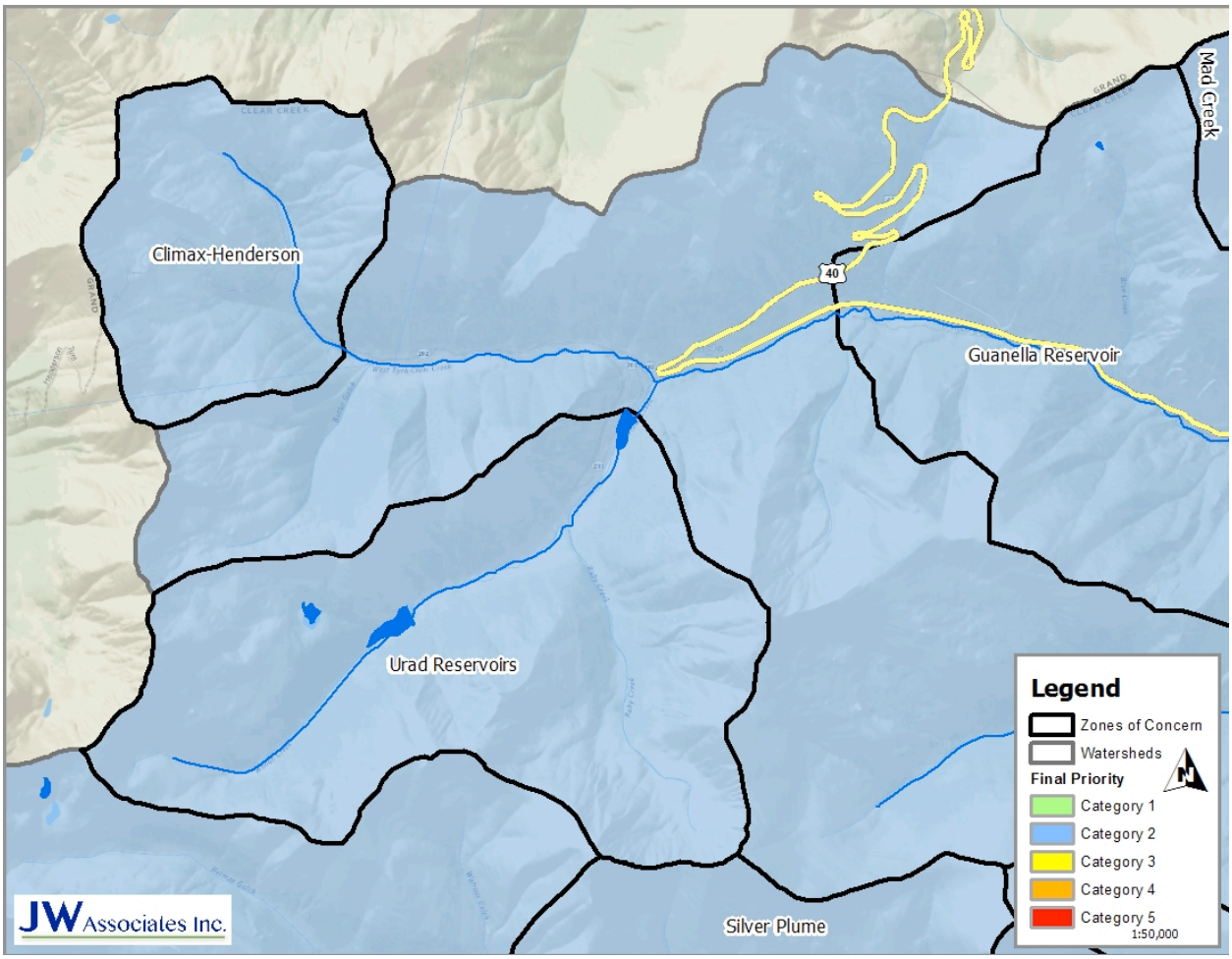


Figure 25. Upper West Fork Clear Creek ZoC Watershed Priority

Upper West Fork Clear Creek Slopes

The Climax-Henderson ZoC is covered by relatively steep slopes (Figure 26). There is a large area of shallower slopes in the western portion of that ZoC. The Urad Reservoirs ZoC is mostly steep slopes, with shallower slopes mostly surrounding the streams in the ZoC (Figure 26).

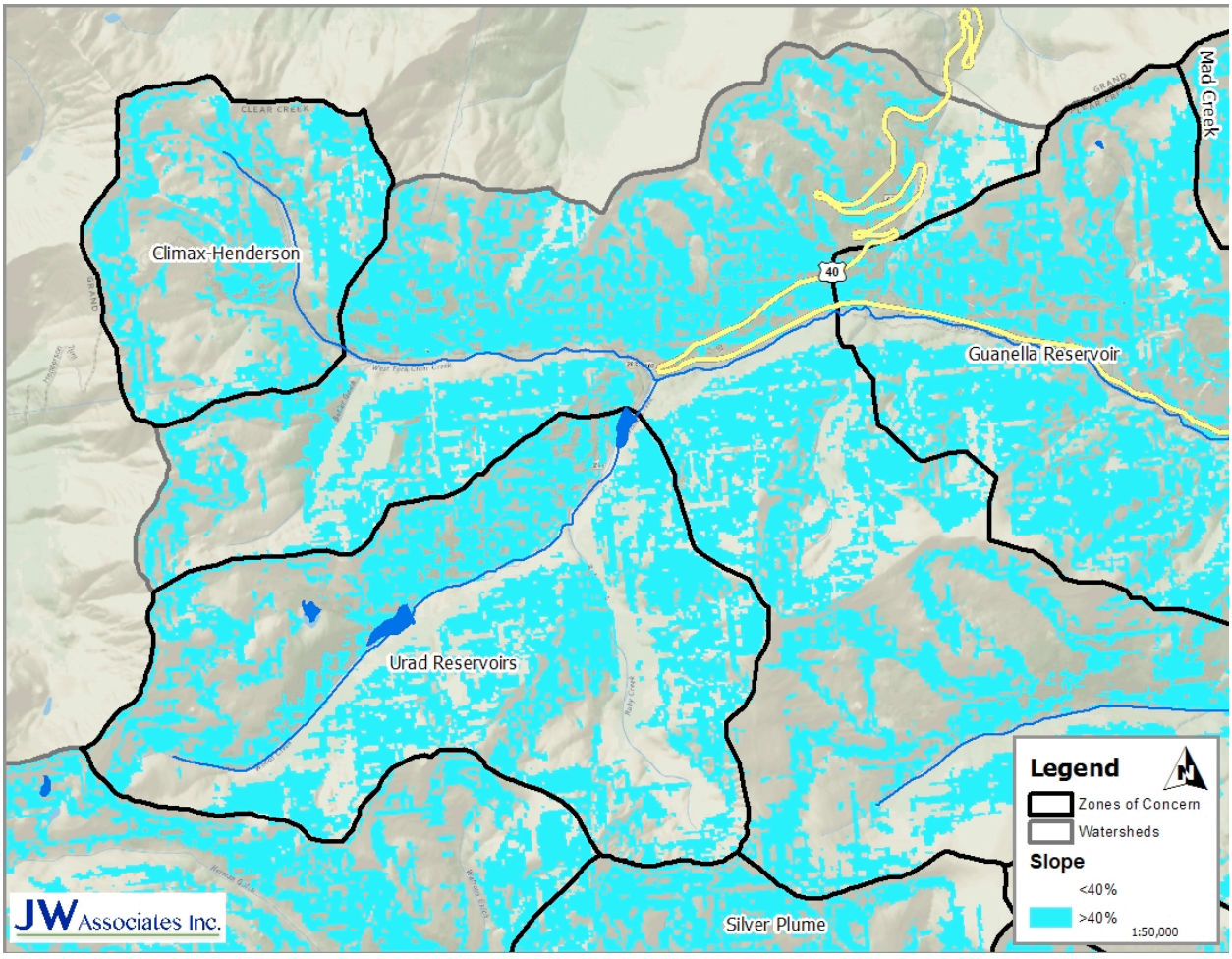


Figure 26. Upper West Fork Clear Creek ZoC Slope

Upper West Fork Clear Creek Special Management Areas

The northern portion of the Climax-Henderson ZoC is covered by the Vasquez Adjacent Roadless Area (Figure 27) with most of that roadless area also classified as Upper Tier. All the NFS lands in the Urad Reservoirs ZoC are within the Bard Creek Roadless Area (Figure 27) with most of that roadless area also classified as Upper Tier.

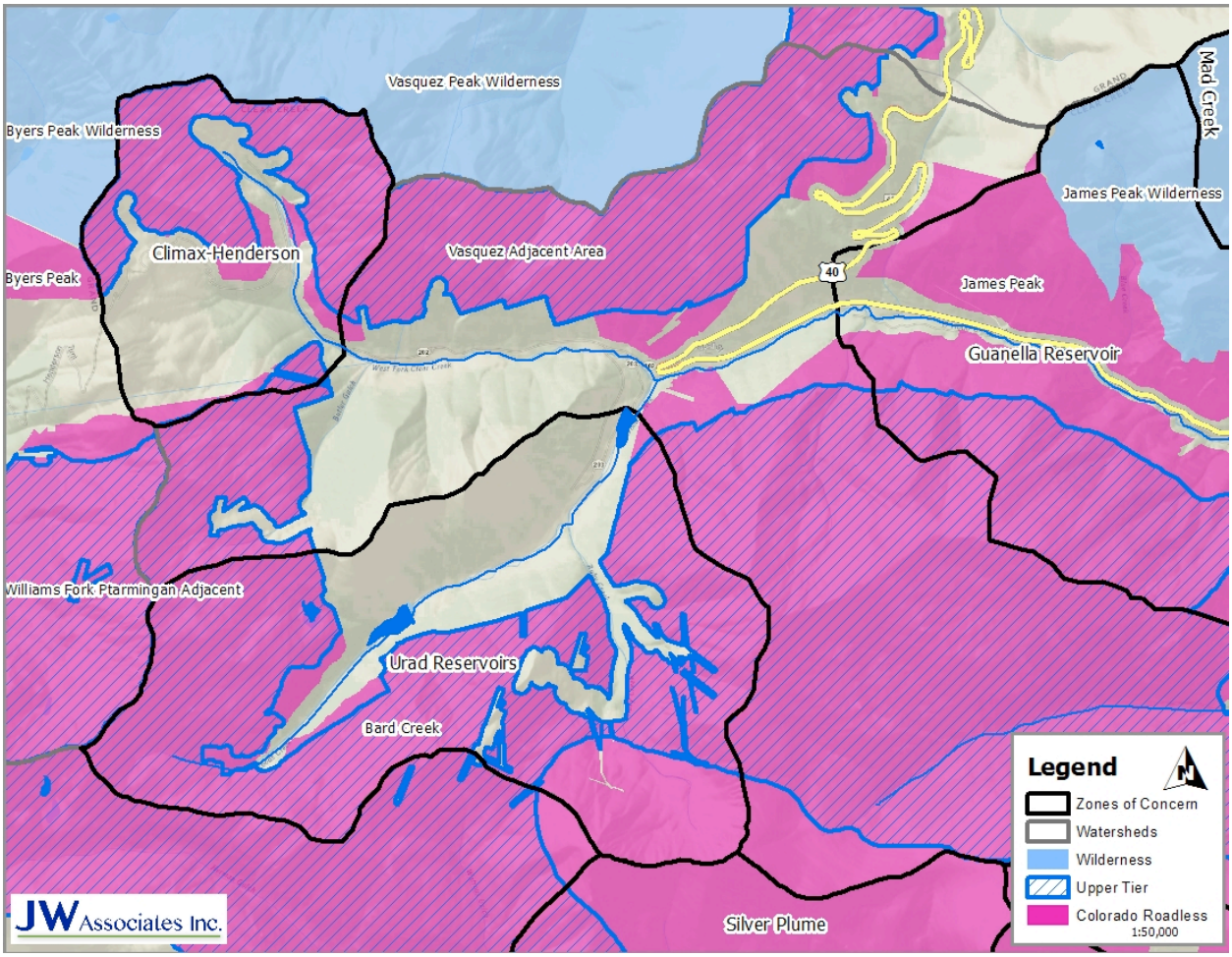


Figure 27. Upper West Fork Clear Creek ZoC Special Areas

Upper West Fork Clear Creek Vegetation

The lower elevations of the Climax-Henderson ZoC is dominated by spruce-fir, with some areas of alpine vegetation high in the ZoC (Figure 28). The Urad Reservoirs ZoC is dominated by spruce-fir forests with some small areas of aspen at the lowest elevations. Both ZoC contain large areas of rock, snow and ice at the highest elevations (Figure 28).

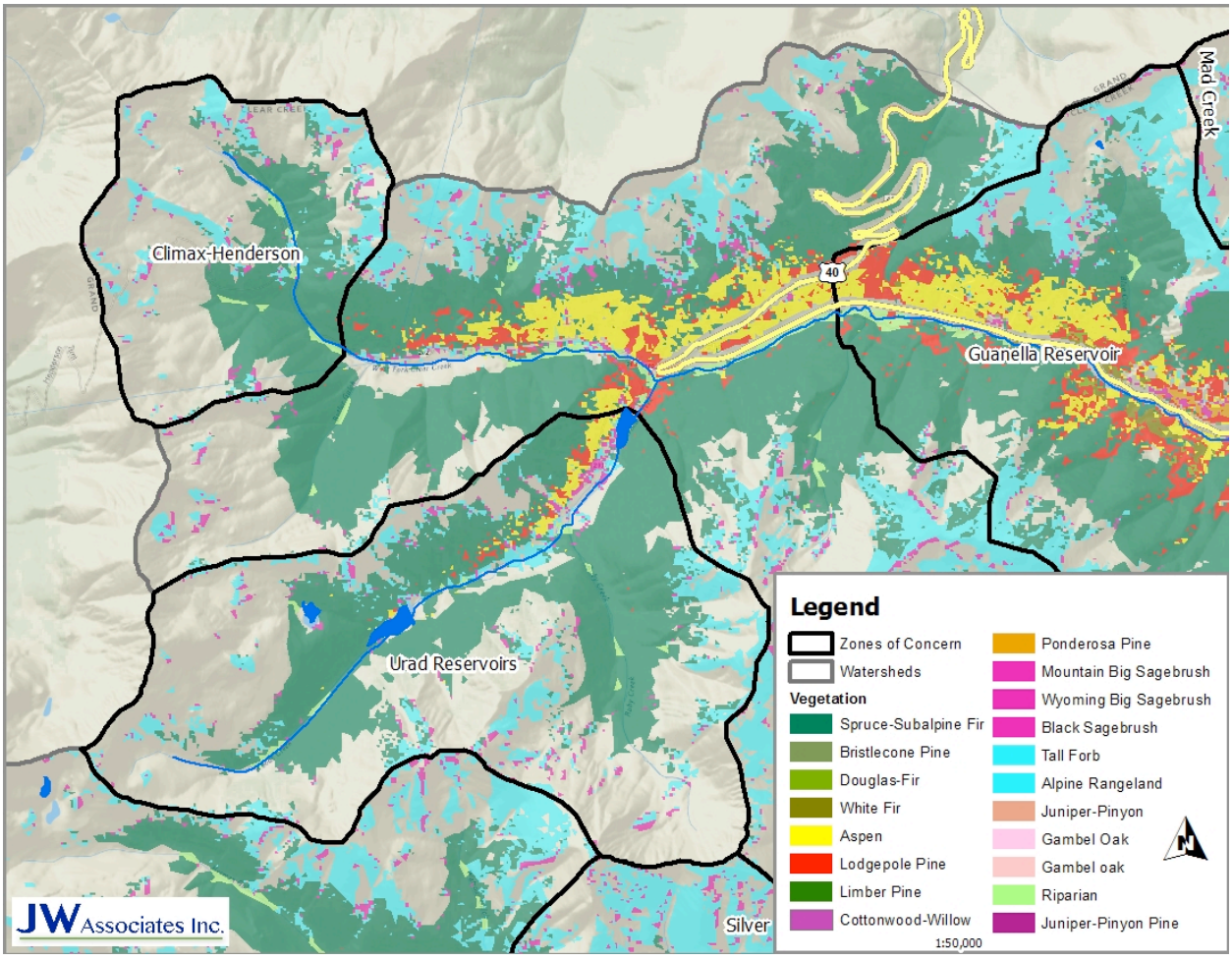


Figure 28. Upper West Fork Clear Creek ZoC Vegetation

Upper West Fork Clear Creek Access

There are some existing roads in the Climax-Henderson ZoC (Figure 29) mostly along stream corridors. Access in the Urad Reservoirs ZoC is limited to one access road running next to the stream and a mid-slope road on private lands north of Woods Creek.

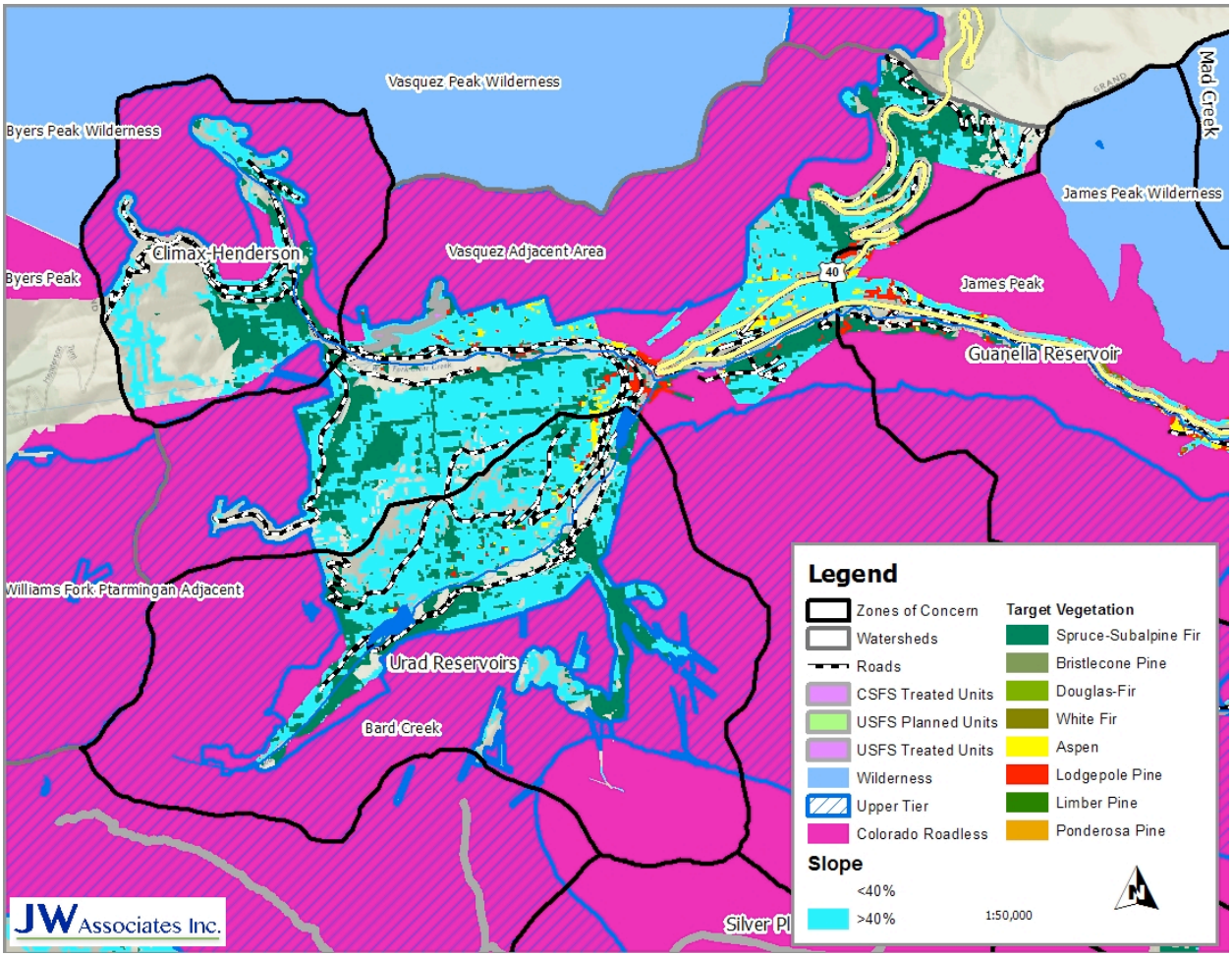


Figure 29. Upper West Fork Clear Creek ZoC Opportunities

Upper West Fork Clear Creek Opportunities

Within the Climax-Henderson ZoC management opportunities are highly constrained because of the lack of forested area, limited access within the forested area and Upper Tier roadless designations. One approach would be to develop an information and education plan in conjunction with the US Forest Service to inform hikers and other visitors about the importance of the area's watersheds and the danger of wildfire to water quality. Climax-Henderson should work with the US Forest Service to develop and implement fire management

plans that could allow natural fires of lower intensities to burn within this watershed to create greater diversity and reduce fuels. There may be an opportunity to create a fuel break along County Road 202, which is between the Bard Creek and Vasquez Adjacent Roadless Areas.

The Urad Reservoirs ZoC contains Lower Urad Reservoir and Upper Urad Reservoir. The area above Lower Urad Reservoir has some opportunities. North of Woods Creek is private land, has better access and is not constrained by Roadless Areas, however this area appears to have a lower forest canopy density and the existing roads provide some good existing fuel breaks. The forested slopes south of Woods Creek appear to present a higher hazard to Lower Urad Reservoir. Most of the area south of Woods Creek is in the Bard Creek Roadless Area with an Upper Tier designation. Therefore any forest treatments would have to be below the roadless areas designated as Upper Tier. There are some opportunities with a road at the bottom of the slope and another road that runs up into the roadless area. The forest in that area is spruce-fir which may present some additional constraints.

Upper Urad Reservoir has relatively dense forests on both sides of Woods Creek, however the roadless areas constraint forest management activities on both sides upstream of the reservoir. There is an existing road that runs past the reservoir and upstream next to Woods Creek. A fuelbreak could be considered in along that road. One approach would be to develop an information and education plan in conjunction with the US Forest Service to inform hikers and other visitors about the importance of the area's watersheds and the danger of wildfire to water quality. The City of Golden should work with the US Forest Service to develop and implement fire management plans that could allow natural fires of lower intensities to burn within this watershed to create greater diversity and reduce fuels.

Lower West Fork Clear Creek ZoC

This section includes the Guanella Reservoir, Mad Creek, and Mill Creek ZoC because they are adjacent (Figure 30). The Mill Creek ZoC is not located within the Lower West Fork Clear Creek. Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

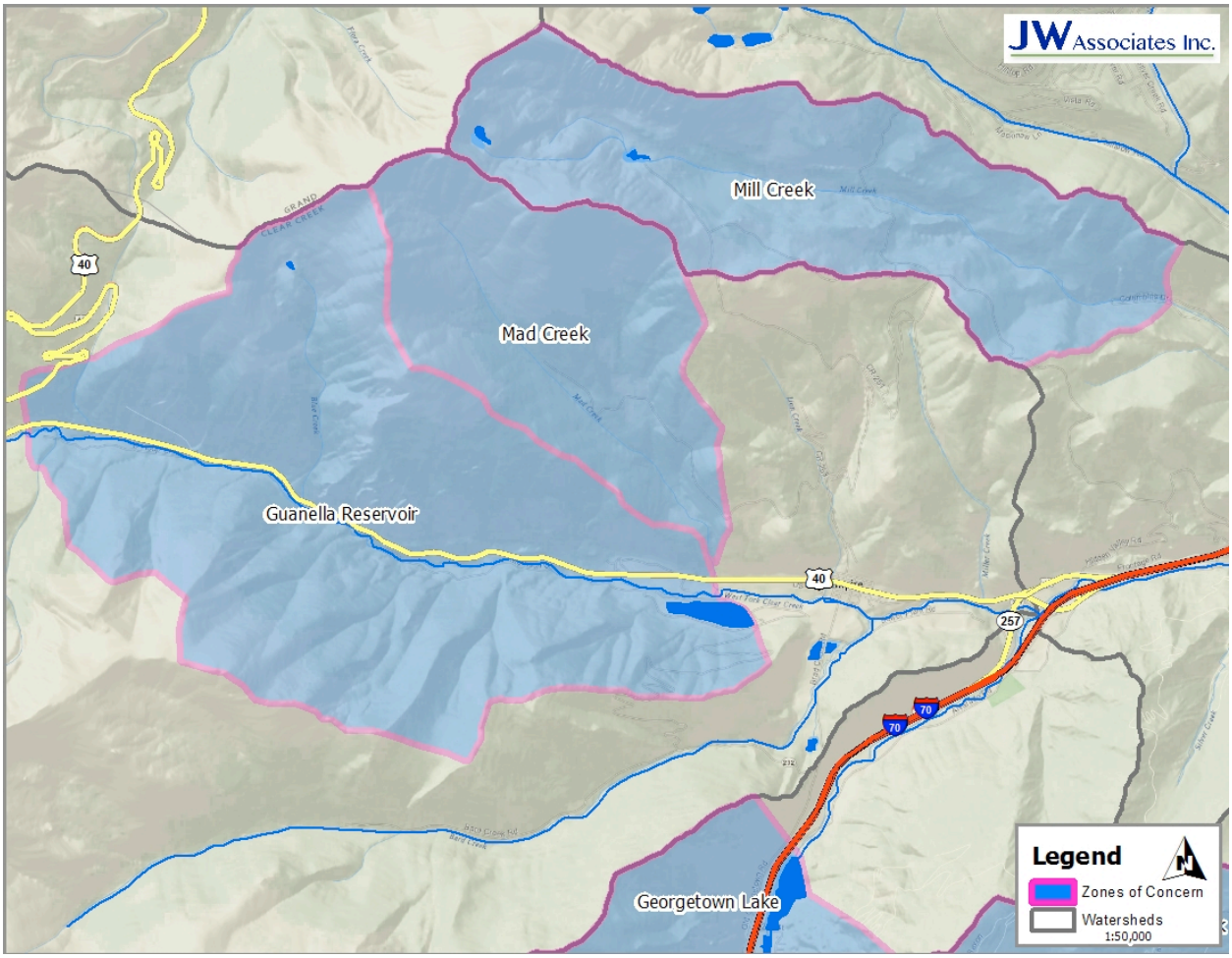


Figure 30. Lower West Fork Clear Creek ZoC Location

Lower West Fork Clear Creek Ownership

The Guanella Reservoir ZoC is mostly NFS lands except for some private lands surrounding Guanella Reservoir and a small area upstream (Figure 31). The Mad Creek ZoC is almost entirely NFS lands with only one small area of private land. The Mill Creek ZoC is mostly NFS lands with some small area of private lands. There is also some Colorado State Land Board land covers a small portion of the ZoC (Figure 31).

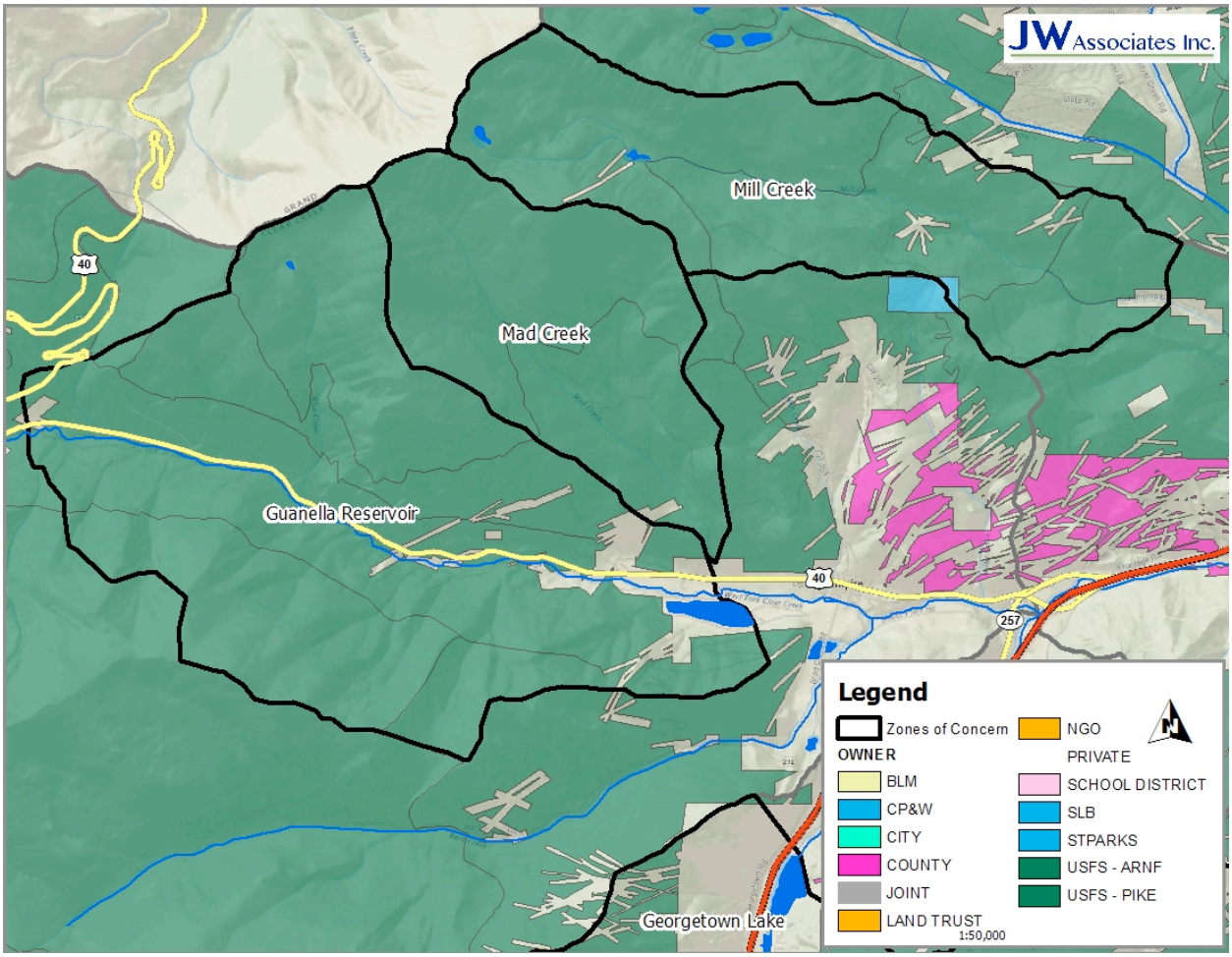


Figure 31. Lower West Fork Clear Creek ZoC Ownership

Lower West Fork Clear Creek Watershed Priority

The Guanella Reservoir and Mad Creek ZoC are within the West Fork Clear Creek watershed that is ranked as Blue (Category 2) overall (Figure 32). It is also ranked as Orange (Category 4) for Soil Erodibility. The Mill Creek ZoC is within the Mill Creek-Clear Creek watershed is ranked as Red (Category 5 - highest) overall (Figure 32). It is also ranked as Red (Category 5 - highest) for Wildfire Hazard, Flooding/Debris Flow Hazard and Composite Hazard. The Mill Creek-Clear Creek watershed is also ranked as Orange (Category 4) for Soil Erodibility.

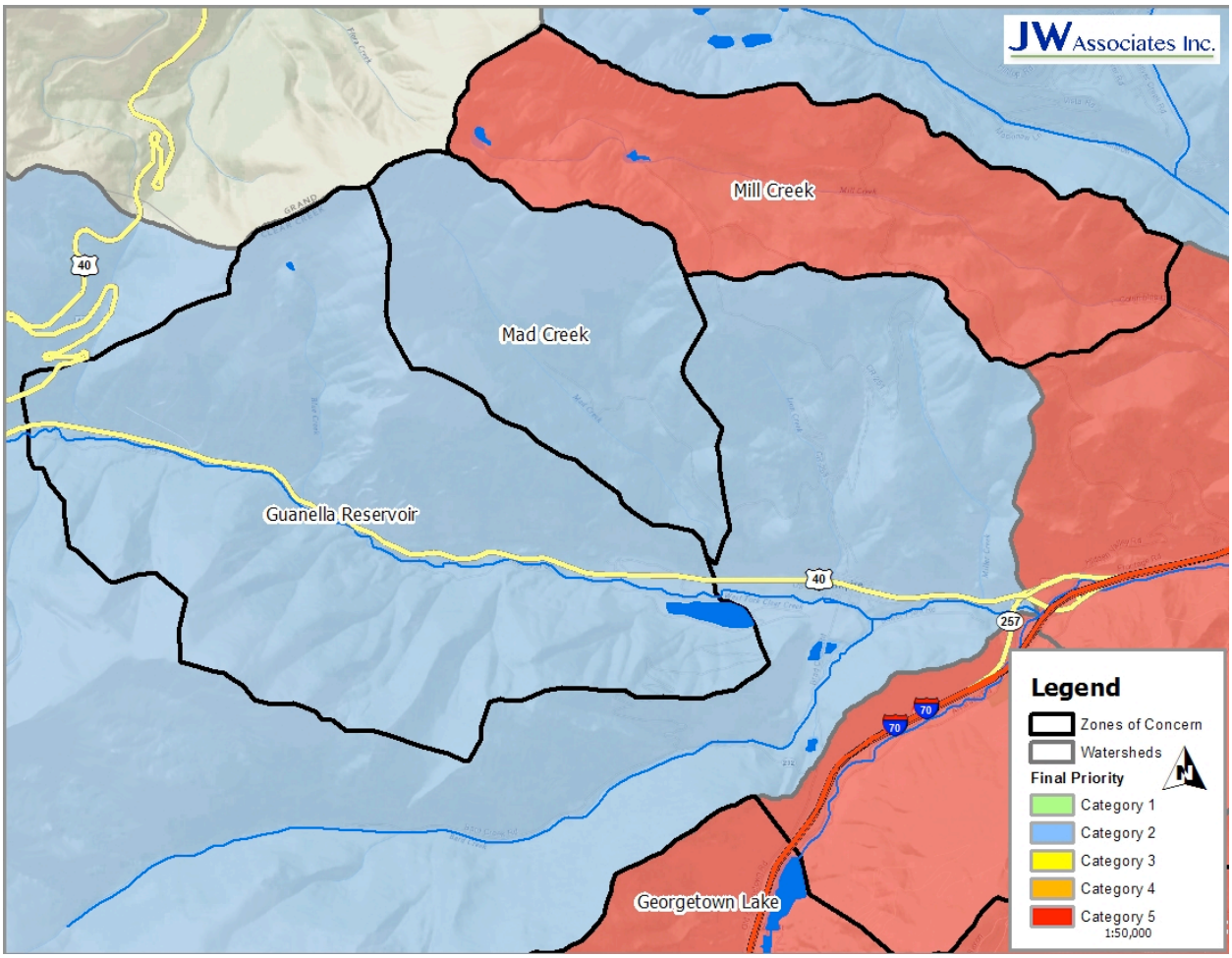


Figure 32. Lower West Fork Clear Creek ZoC Watershed Priority

Lower West Fork Clear Creek Slopes

The Guanella Reservoir ZoC has mostly steep slopes throughout with some shallower slopes lower in the ZoC surrounding the stream channel and around the reservoir (Figure 33). The Mad Creek ZoC also has mostly steep slopes with shallower slopes surrounding Mad Creek lower in the ZoC. The Mill Creek ZoC has mostly shallower slopes with some steeper slopes at the highest elevations (Figure 33).

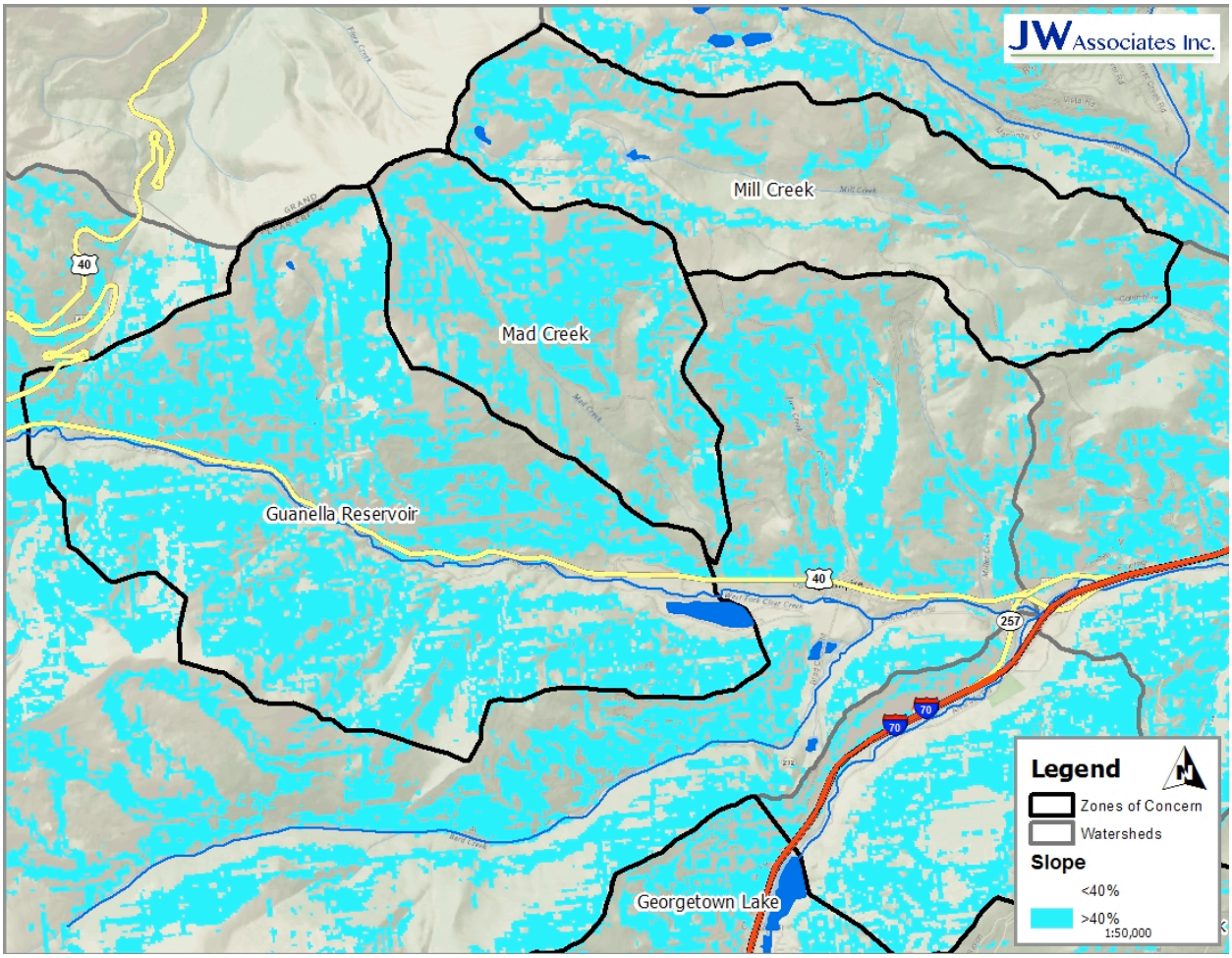


Figure 33. Lower West Fork Clear Creek ZoC Slope

Lower West Fork Clear Creek Special Management Areas

The Guanella Reservoir ZoC contains the Bard Creek Roadless Area south of West Fork Clear Creek with the upper portions designated as Upper Tier (Figure 34). The portion of the Guanella Reservoir ZoC north of West Fork Clear Creek contains the James Peak Wilderness Area higher in the ZoC and the James Peak Roadless Area below the wilderness. The Mad Creek and Mill Creek ZoC both are covered by the James Peak Wilderness Area in the upper elevations with some smaller areas of the James Peak Roadless Area below the wilderness (Figure 34).

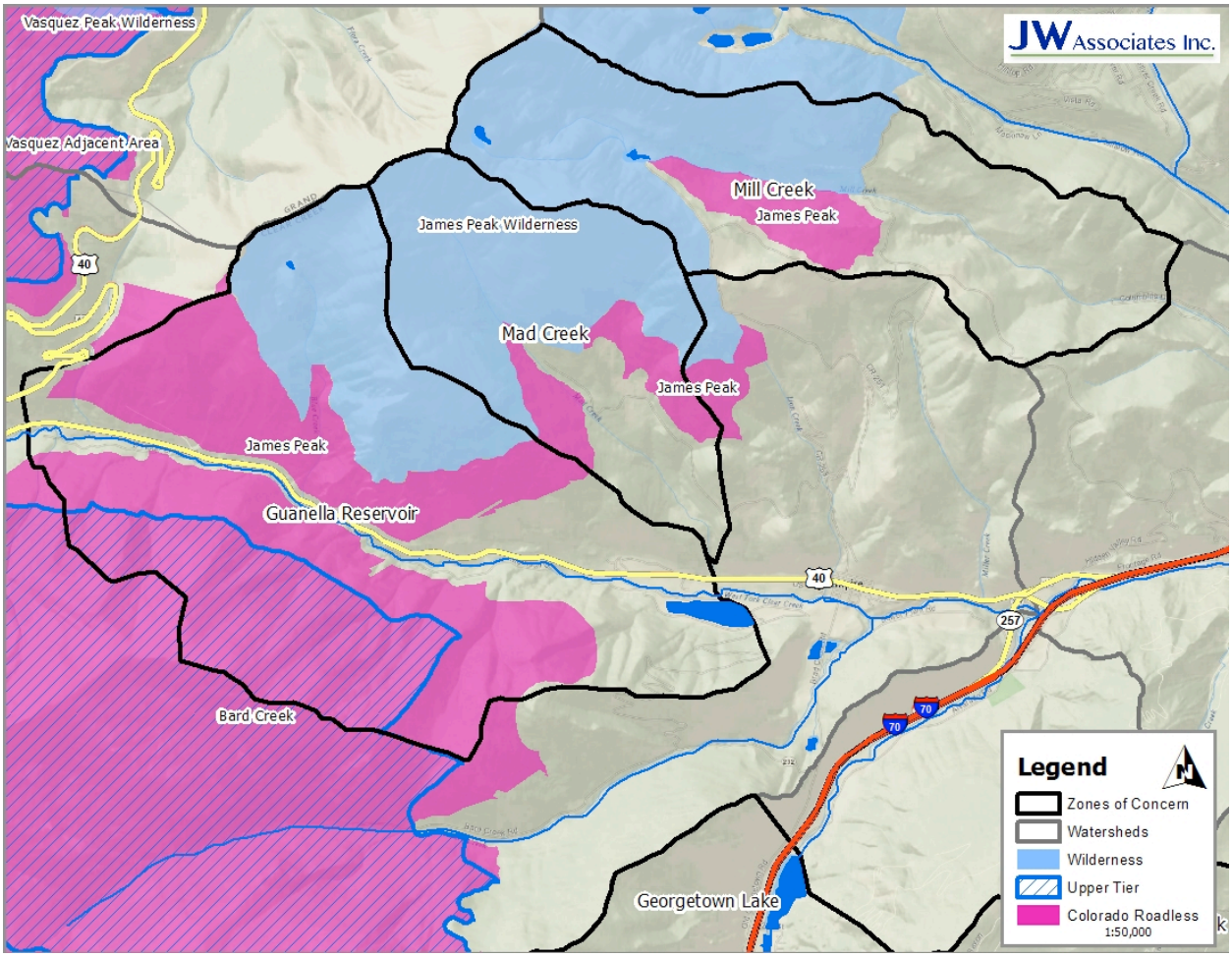


Figure 34. Lower West Fork Clear Creek ZoC Special Areas

Lower West Fork Clear Creek Vegetation

The Guanella Reservoir ZoC has large areas of spruce-fir forest, with mostly aspen surrounding West Fork Clear Creek higher in the ZoC (Figure 35). Lower in the Guanella Reservoir ZoC aspen mixes with lodgepole pine and some Douglas-fir near the reservoir. The lower portions of the Mad Creek ZoC are dominated by lodgepole pine, transitioning to a band of spruce-fir and then alpine at the highest elevations. The Mill Creek ZoC is also dominated by lodgepole pine at lower elevations transitioning to spruce-fir and finally alpine at the highest elevations (Figure 35).

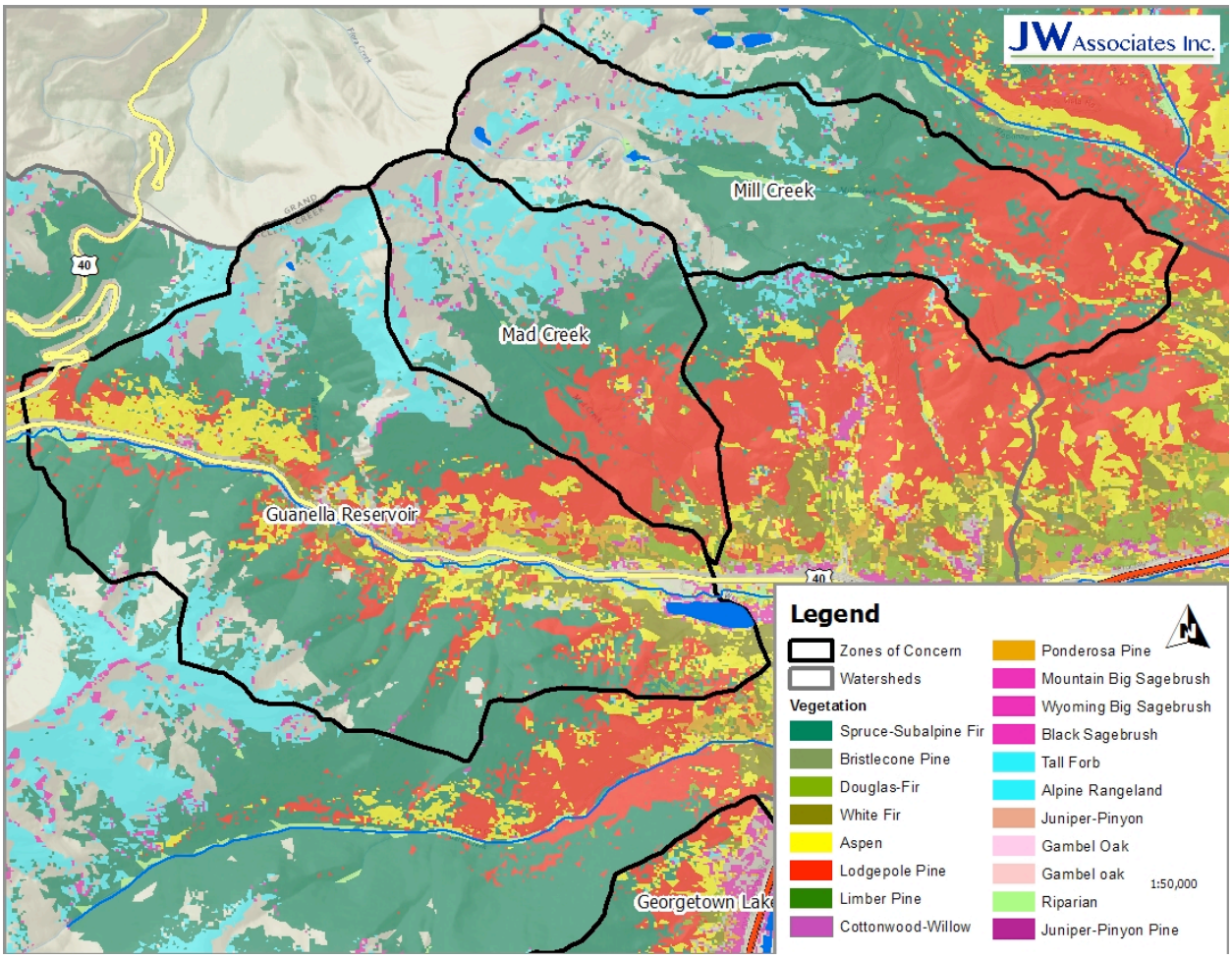


Figure 35. Lower West Fork Clear Creek ZoC Vegetation

Lower West Fork Clear Creek Access

There are existing roads in all three ZoC throughout the private lands (Figure 36). There are basically no existing roads on NFS lands.

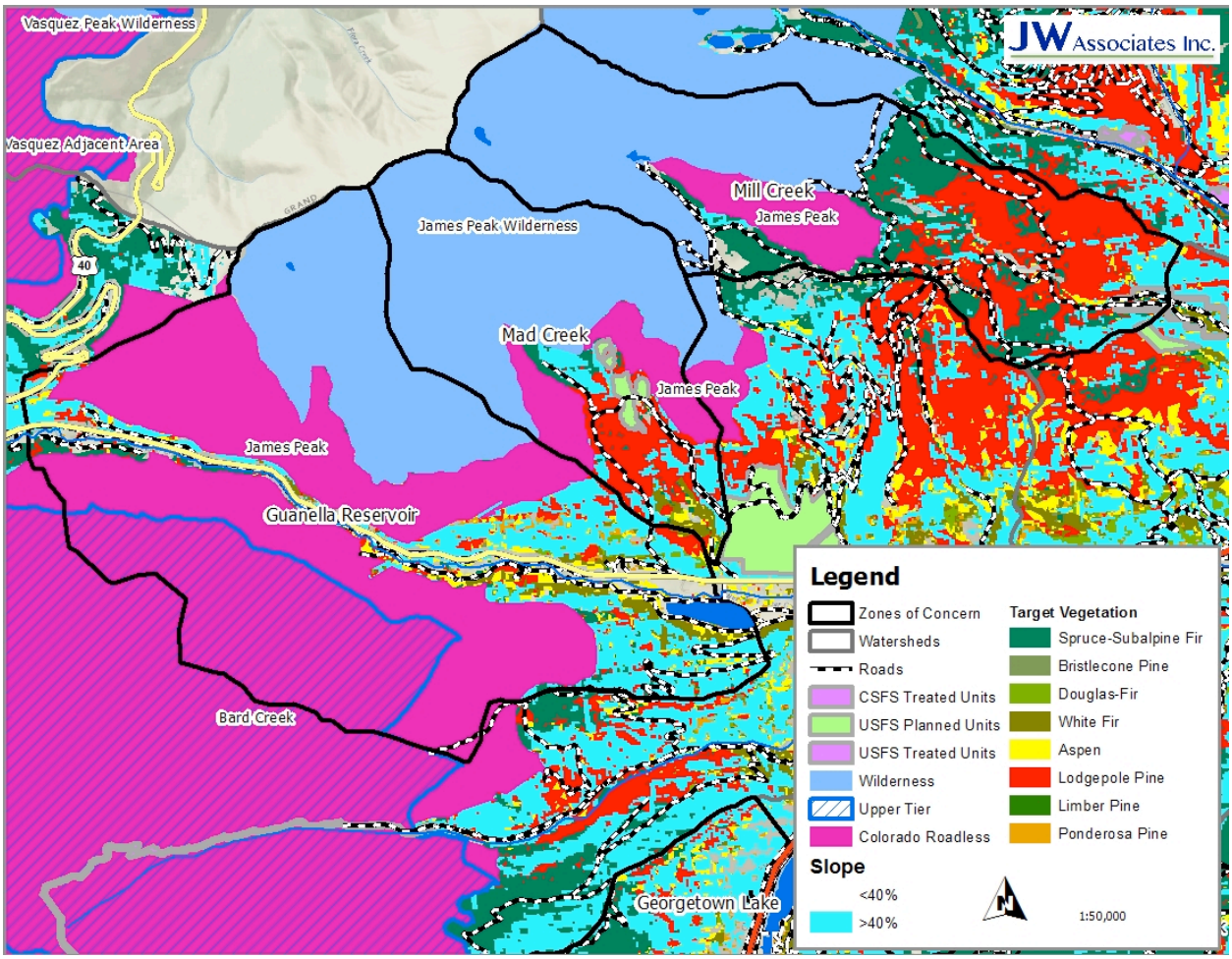
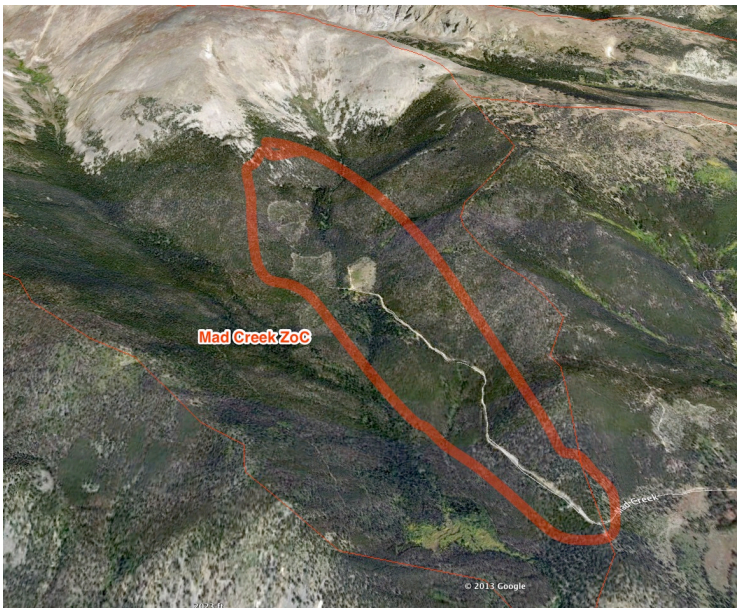


Figure 36. Lower West Fork Clear Creek ZoC Opportunities

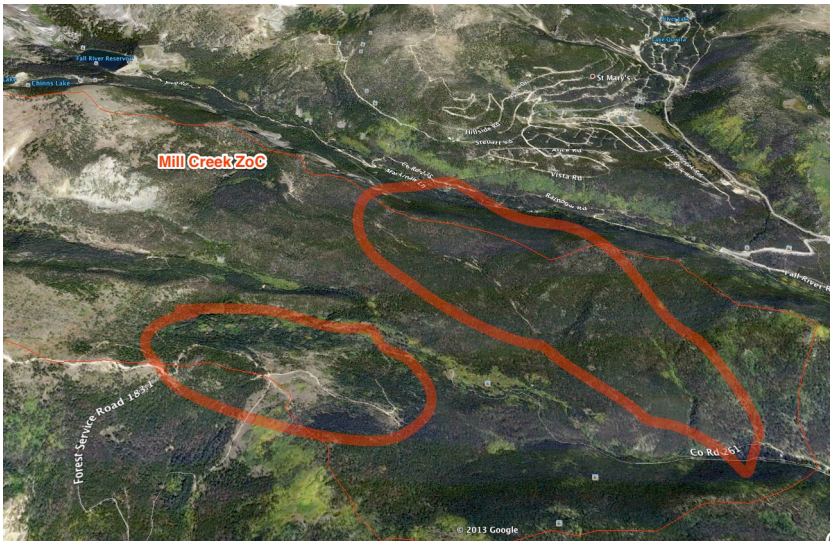
Lower West Fork Clear Creek Opportunities

The Guanella Reservoir ZoC has some opportunities for forest management. The area immediately south of the reservoir has an existing road that runs through a stand of lodgepole pine, aspen and spruce-fir. Treatments in this area should be focused on increasing age-class diversity and regenerating aspen. Treatments in other areas upstream of the reservoir should also focus on aspen regeneration or enhancement. Treatments upstream of the reservoir are constrained by roadless areas, but some treatments could be accomplished in these areas.

The Mad Creek ZoC has had some recent forest treatments completed. Additional treatments along the access road for these treatments could create an effective fuel break and bring some diversity to this ZoC. There is also a road on the west side of this ZoC that could be investigated to determine if treatments could be accomplished there. Areas above the existing treatments and roads are constrained by roadless areas and steep slopes.



The Mill Creek ZoC has some existing roads that run through the most densely forested sections. These areas should be investigated for fuelbreaks and other forest treatments. With the large amount of lodgepole pine in these ZoC, focus should be placed on developing age diversity through carefully planned and located clearcuts and patchcuts. Treatments should also promote the development of additional aspen stands by placing many of the lodgepole harvest units in areas with a remnant of aspen in the understory. Also, maintain current aspen stands through conifer removal and regeneration harvests.



Georgetown Area ZoC

The Georgetown Area ZoC include Georgetown Lake, Silver Plume, South Clear Creek, and Lower Cabin and Clear Lake ZoC that are adjacent or overlapping and are combined in this discussion (Figure 37). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

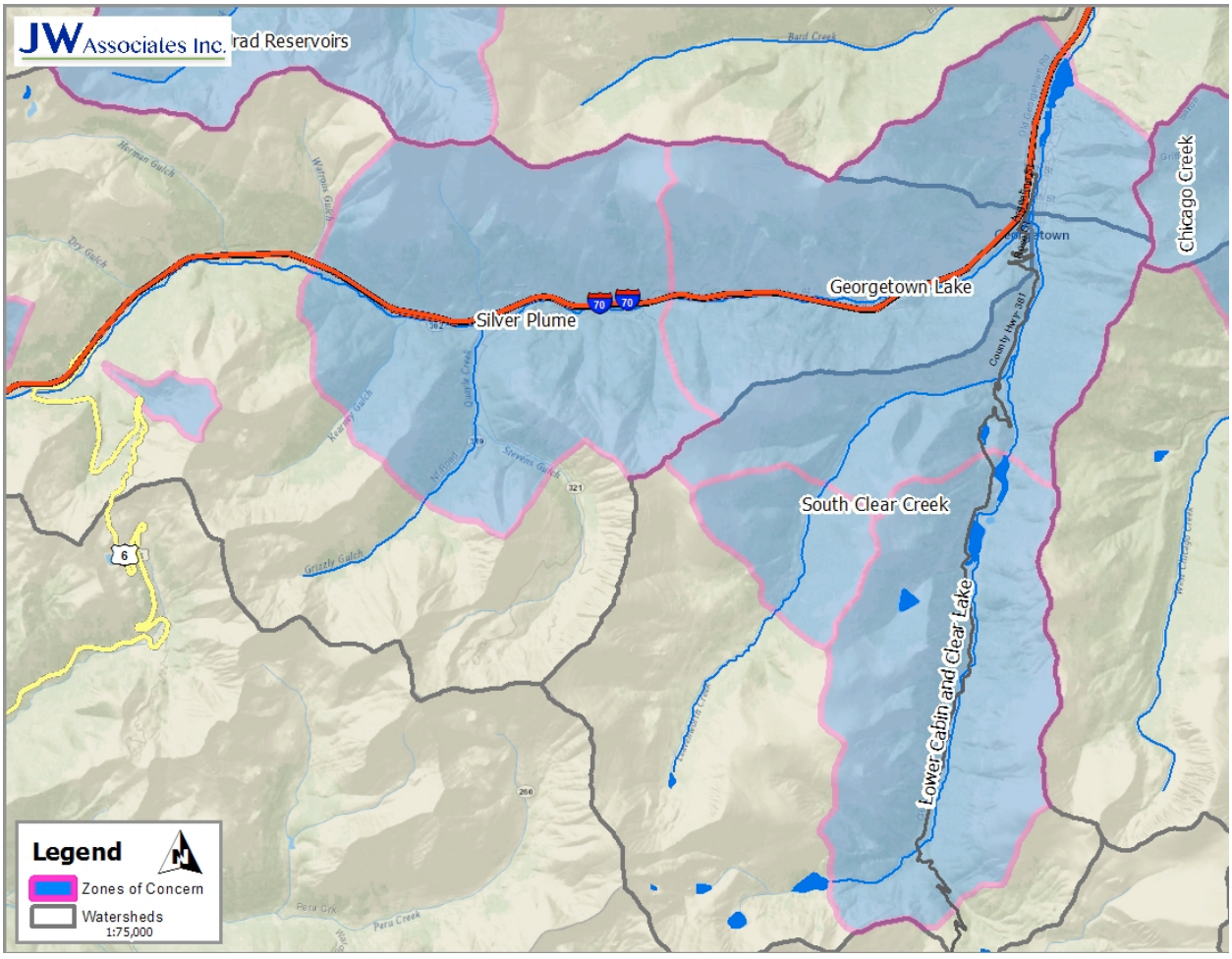


Figure 37. Georgetown Area ZoC Location

Georgetown Area ZoC Ownership

The Silver Plume ZoC is mostly NFS lands with some large areas of private land and one large piece of Colorado State Land Board (Figure 38). The Georgetown Lake ZoC is mostly private with the upper elevations in NFS lands. The Lower Cabin and Clear Lake ZoC is nearly all NFS lands. The South Clear Creek ZoC is mostly NFS lands with a large section of private lands in the lowest portion of the ZoC. The South Clear Creek ZoC also contains a section of Clear Creek County Open Space Commission land (Figure 38).

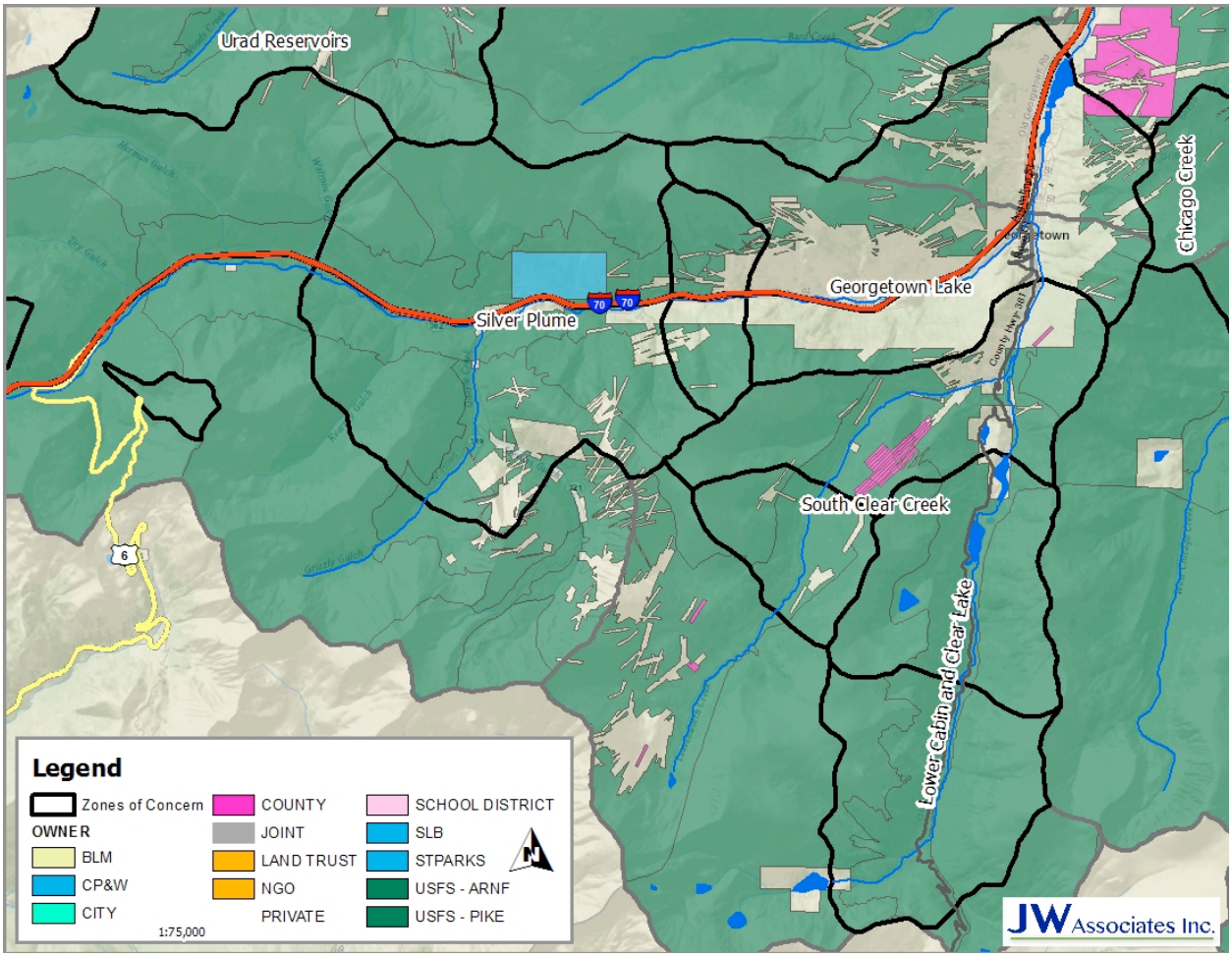


Figure 38. Georgetown Area ZoC Ownership

Georgetown Area ZoC Watershed Priority

The Silver Plume and the upper portions of the Georgetown Lake ZoC are within the Headwaters Clear Creek watershed that is ranked as Blue (Category 2) overall. It is also ranked as Orange (Category 4) for Soil Erodibility. The lower portion of the Georgetown Lake ZoC is within the Silver Gulch-Clear Creek watershed that is ranked as Red (Category 5 - highest) overall, and for Wildfire Hazard, Flooding/Debris Flow Hazard, Soil Erodibility and Composite Hazard (Figure 39). The Lower Cabin and Clear Lake, and South Clear Creek ZoC are within the South Clear Creek watershed that is ranked as Blue (Category 2) overall (Figure 39).

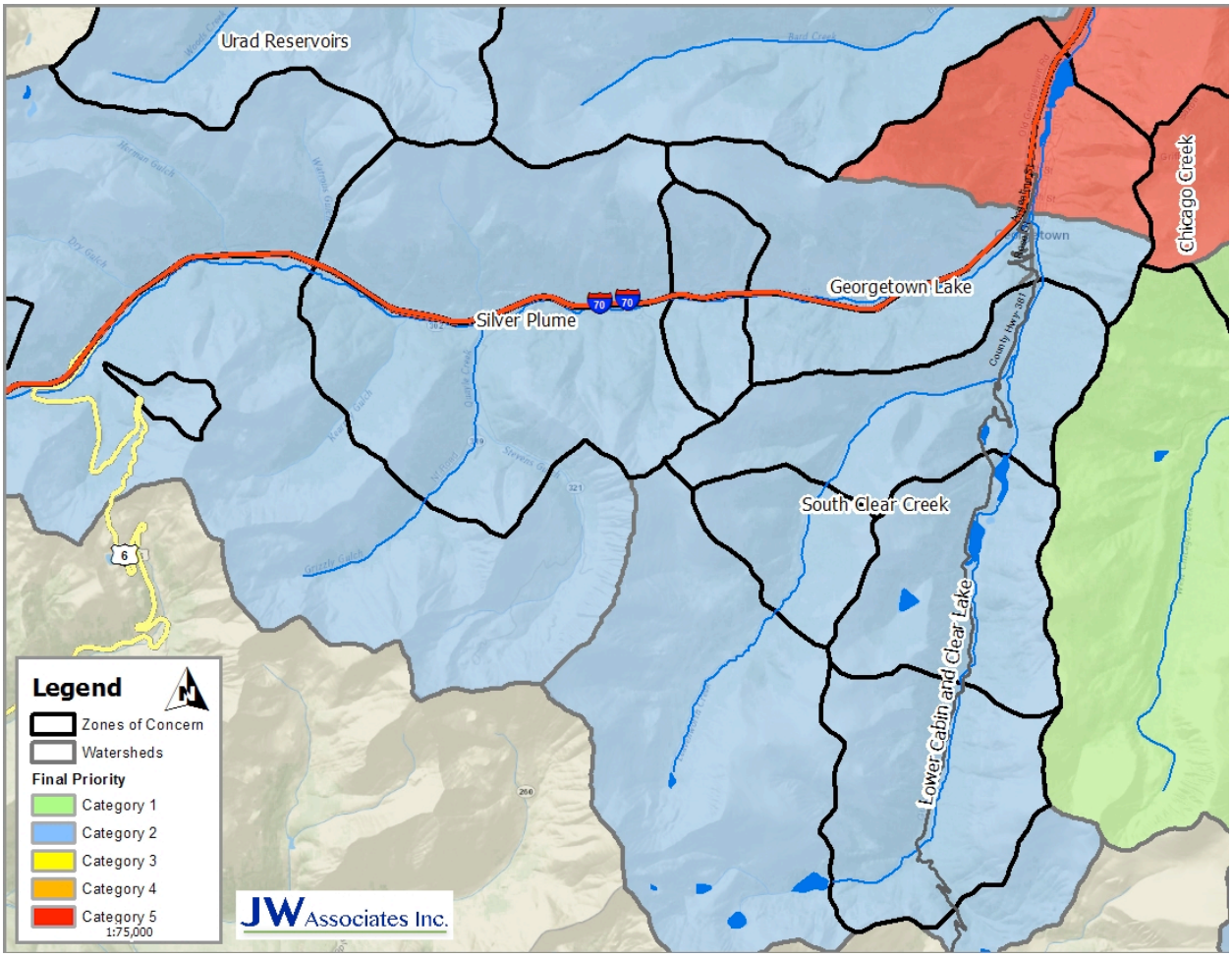


Figure 39. Georgetown Area ZoC Watershed Priority

Georgetown Area ZoC Slopes

The Silver Plume ZoC is dominated by steep slopes (Figure 40). The Georgetown Lake ZoC has large areas of steep slopes with a few areas of shallower slopes. The South Clear Creek ZoC has large areas of steep slopes, with some areas of shallower slopes, especially in upper portions of Leavenworth Creek. The Lower Cabin and Clear Creek ZoC is dominated by steep slopes especially on the west facing slopes. The east facing slopes have some shallower areas at higher elevations (Figure 40).

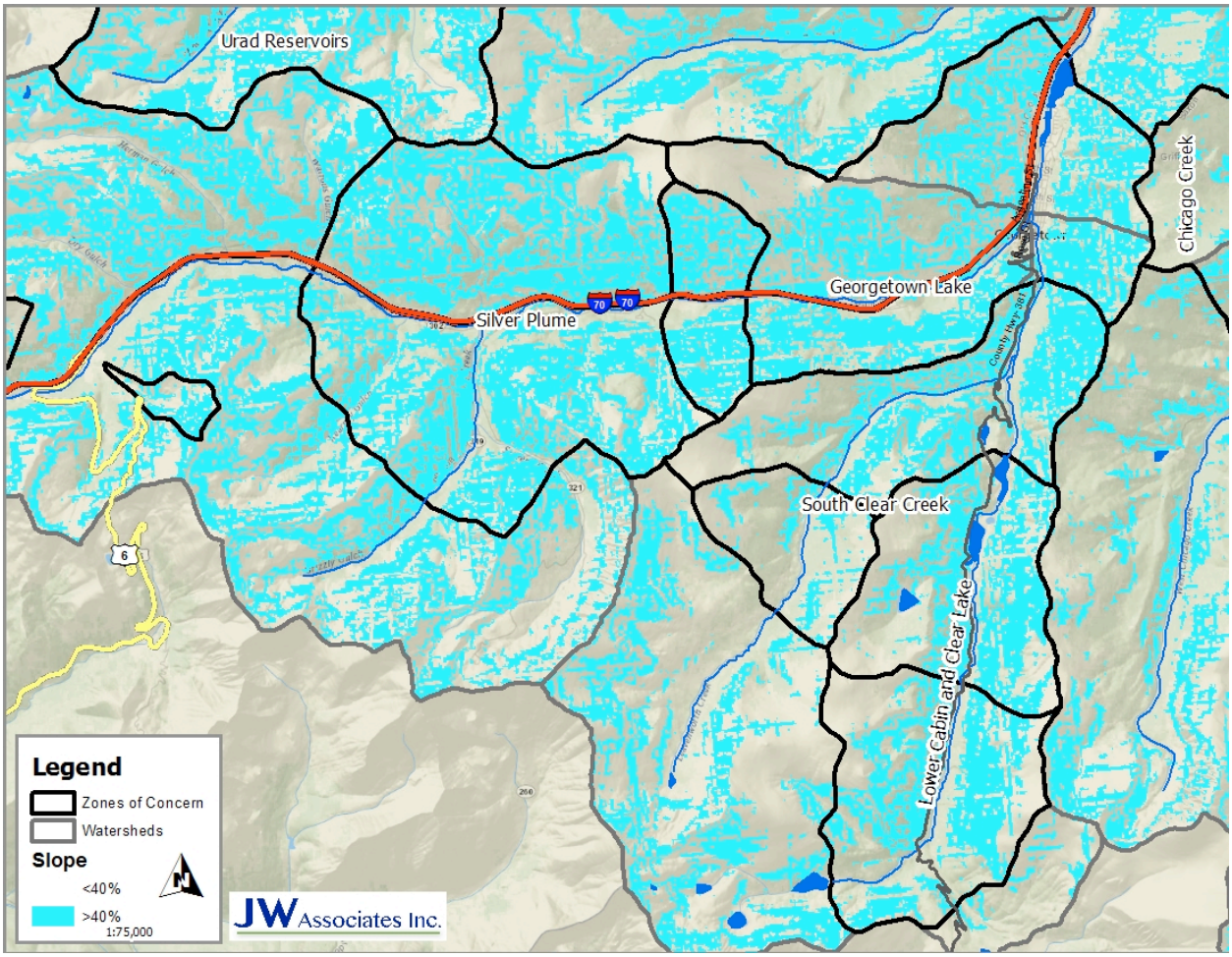


Figure 40. Georgetown Area ZoC Slope

Georgetown Area ZoC Special Management Areas

The Silver Plume ZoC contains the Bard Creek Roadless Area north of Clear Creek, with a small portion having the Upper Tier designation (Figure 41). The Mount Sniktau Roadless Area is south of Clear Creek and west of Grizzly Gulch in the Silver Plume ZoC. The Georgetown Lake ZoC has some small portions of the Bard Creek Roadless Area in the north, and the Mount Evans Adjacent Roadless Area in the east. The South Clear Creek ZoC has the Mount Evans Wilderness Area east of the South Fork of Clear Creek. West of the South Fork of Clear Creek, the Square Top Mountain Roadless Area with Upper Tier designation, covers the South Clear Creek ZoC. However, Leavenworth Creek drainage has no special designations within the South Clear Creek ZoC (Figure 41). The Lower Cabin and Clear Lake ZoC has the Mount Evans Wilderness Area east of the South Fork of Clear Creek and the Square Top Mountain Roadless Area with Upper Tier designation west of the South Fork of Clear Creek.

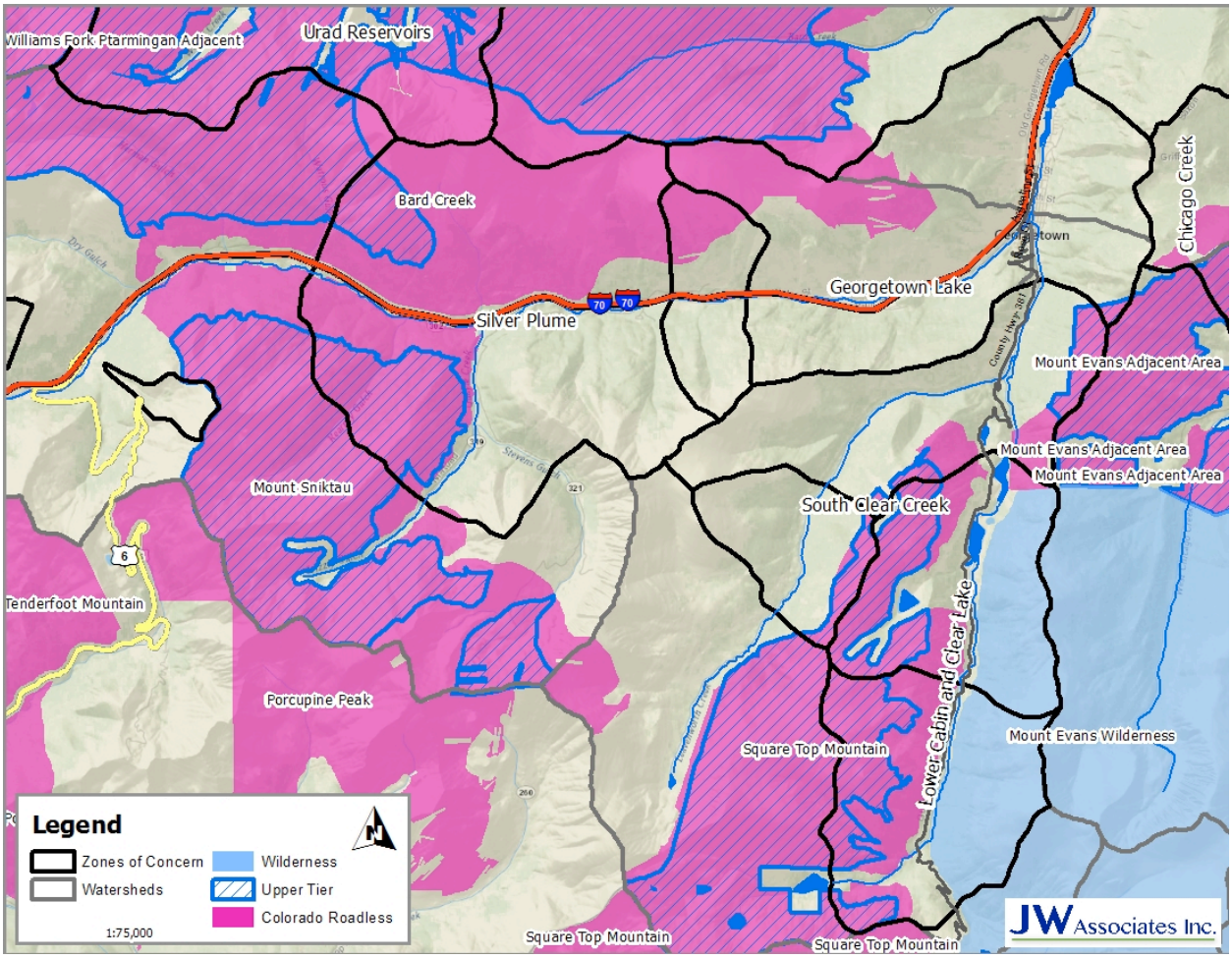


Figure 41. Georgetown Area ZoC Special Areas

Georgetown Area ZoC Vegetation

The Silver Plume ZoC is dominated by spruce-fir forest (Figure 42) with large areas of aspen and lodgepole pine along Clear Creek. The Georgetown Lake ZoC is a mixture of aspen, lodgepole pine and spruce-fir forest, with the spruce-fir occupying the higher elevations below the alpine areas. The South Clear Creek ZoC has a large area of lodgepole pine along the stream corridor lower in the ZoC, transitioning to aspen along the stream corridors higher in the ZoC. The South Clear Creek ZoC is mostly spruce-fir forest above the lodgepole pine and aspen areas. The Lower Cabin and Clear Lake ZoC transitions from mostly aspen lower in the ZoC through a band of spruce-fir to alpine at the highest elevations (Figure 42).

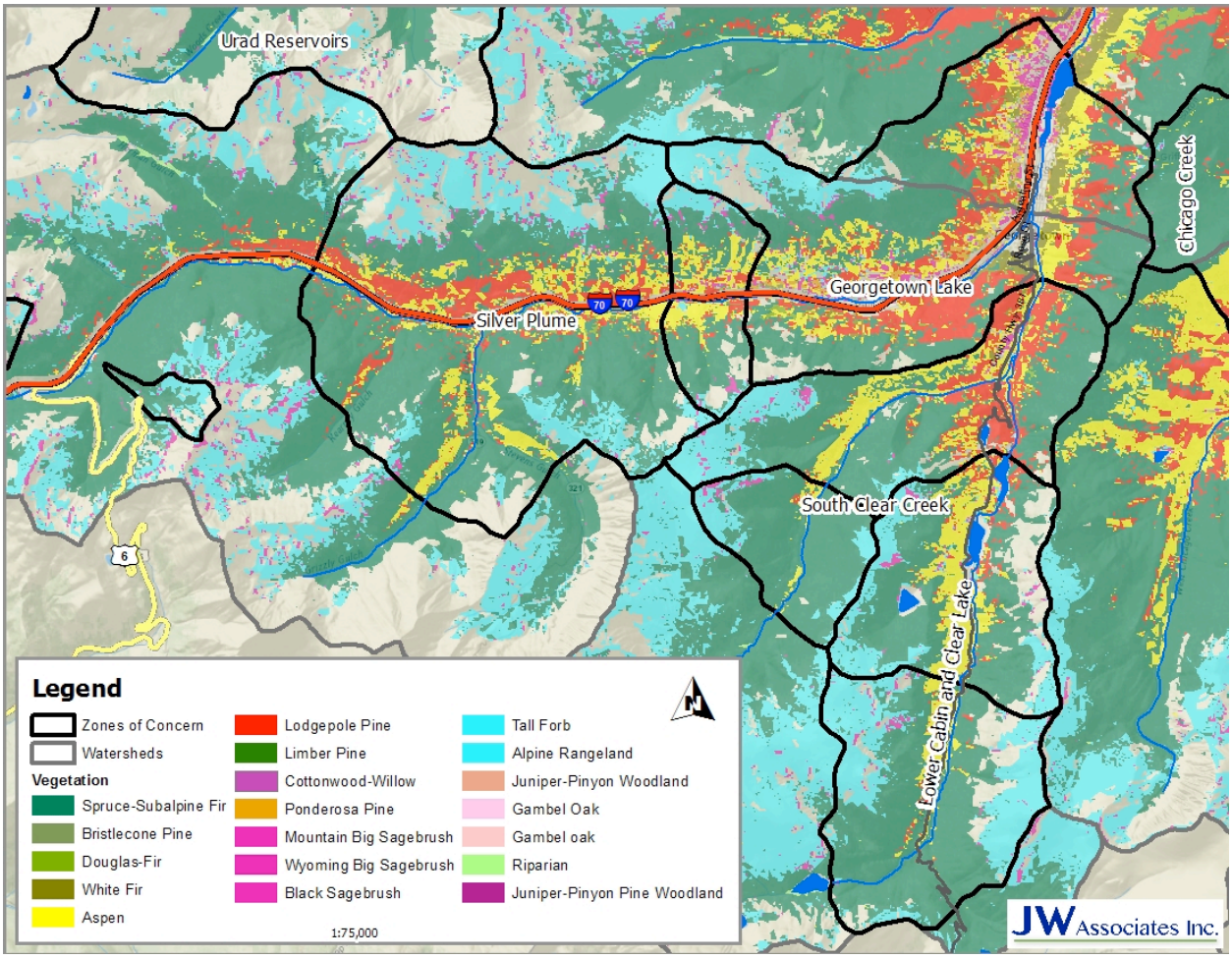


Figure 42. Georgetown Area ZoC Vegetation

Georgetown Area ZoC Access

The Silver Plume ZoC has some existing roads that provide access (Figure 43). The Georgetown Lake ZoC has limited road access, primarily along Clear Creek. The South Clear Creek ZoC has existing roads providing access to some of the private lands, particularly in the western portion of the ZoC. Access in the Lower Cabin and Clear Lake ZoC is mostly limited to areas along South Fork Clear Creek (Figure 43).

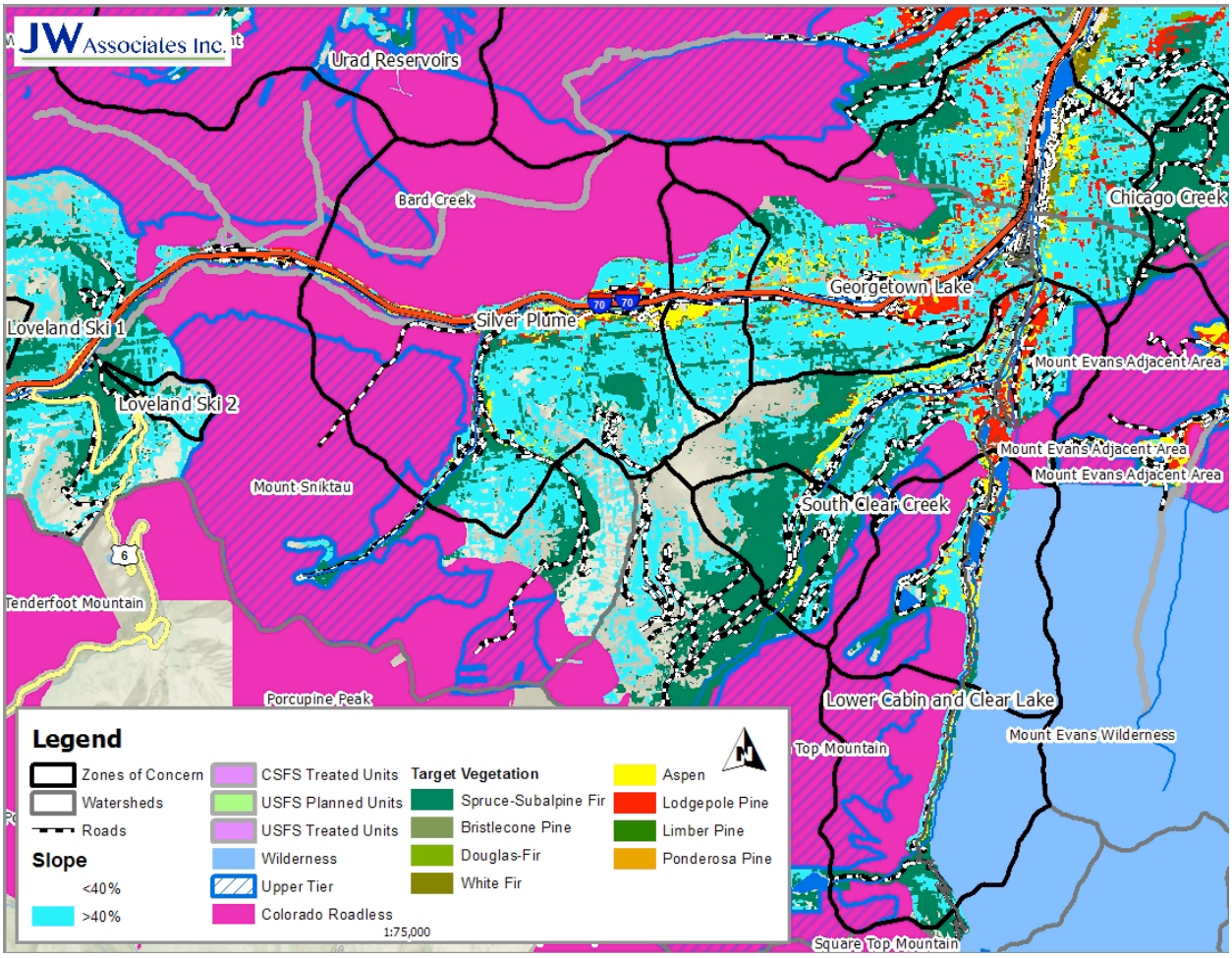


Figure 43. Georgetown Area ZoC Opportunities

Georgetown Area ZoC Opportunities

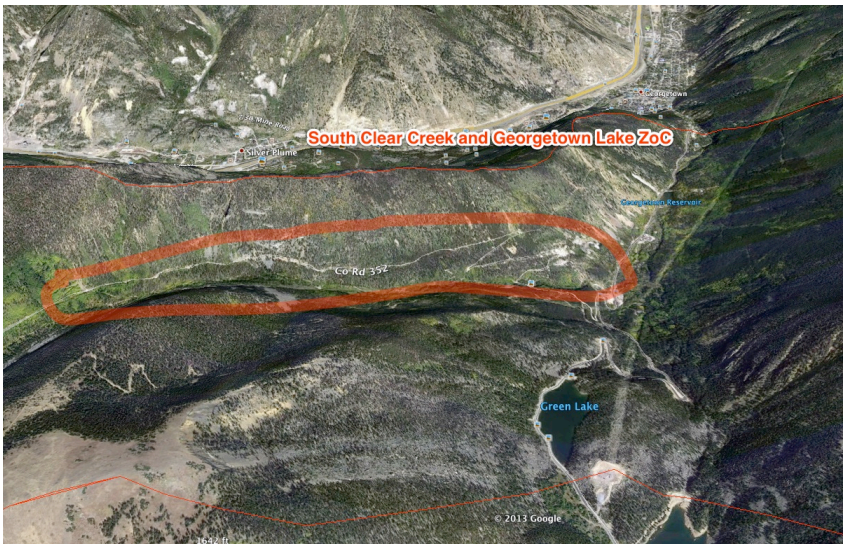
The Silver Plume ZoC appears to have limited opportunities for forest treatments. The areas that have existing access with shallower slopes and target forests, are very limited to a few roadside areas. Treatments would be mostly in spruce-fir and additional constraints, including recreation concerns would need to be considered.

There are some opportunities in the Georgetown Lake ZoC. The most beneficial treatments are those closer to the reservoir and in the more dense forests on north-facing slopes. The Argentine Central Railroad Grade

provides access to an area that could be utilized for aspen enhancement and expansion. The Saxon Mountain Road that climbs the slope just east of Georgetown Lake might be another location for creating some diversity and enhancing aspen.

The South Clear Creek ZoC overlaps with the Georgetown Lake ZoC. An example of an opportunity in this overlap area is along County Road 352. Fuelbreaks and treatments in this area could benefit both ZoC. That area is mostly spruce-fir, but some aspen stands are present that could be enhanced or expanded where they have experienced conifer encroachment.

The Lower Cabin and Clear Lake ZoC appears to have some opportunities. However, there is relatively small band of spruce-fir forest that would be the target for treatments. There is a lack of existing access and the slopes are steep in these areas making treatments difficult and expensive. Development of a pre- and post-fire plan would be a good first step in these ZoC.



For all of these ZoC the water providers should develop an information and education plan in conjunction with the US Forest Service to inform hikers, mountain bikers, users of off-road vehicles and other visitors to the wilderness and roadless areas about the importance of the area's watersheds and the danger of wildfire to water quality. They should also work with the US Forest Service to develop and implement fire management plans that could allow natural fires of lower intensities to burn within these watersheds to create greater diversity and reduce fuels.

Chicago-Soda Creek ZoC

The Chicago Creek, Soda Creek and Hidden Valley ZoC are adjacent or overlapping and are combined in this discussion (Figure 44). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

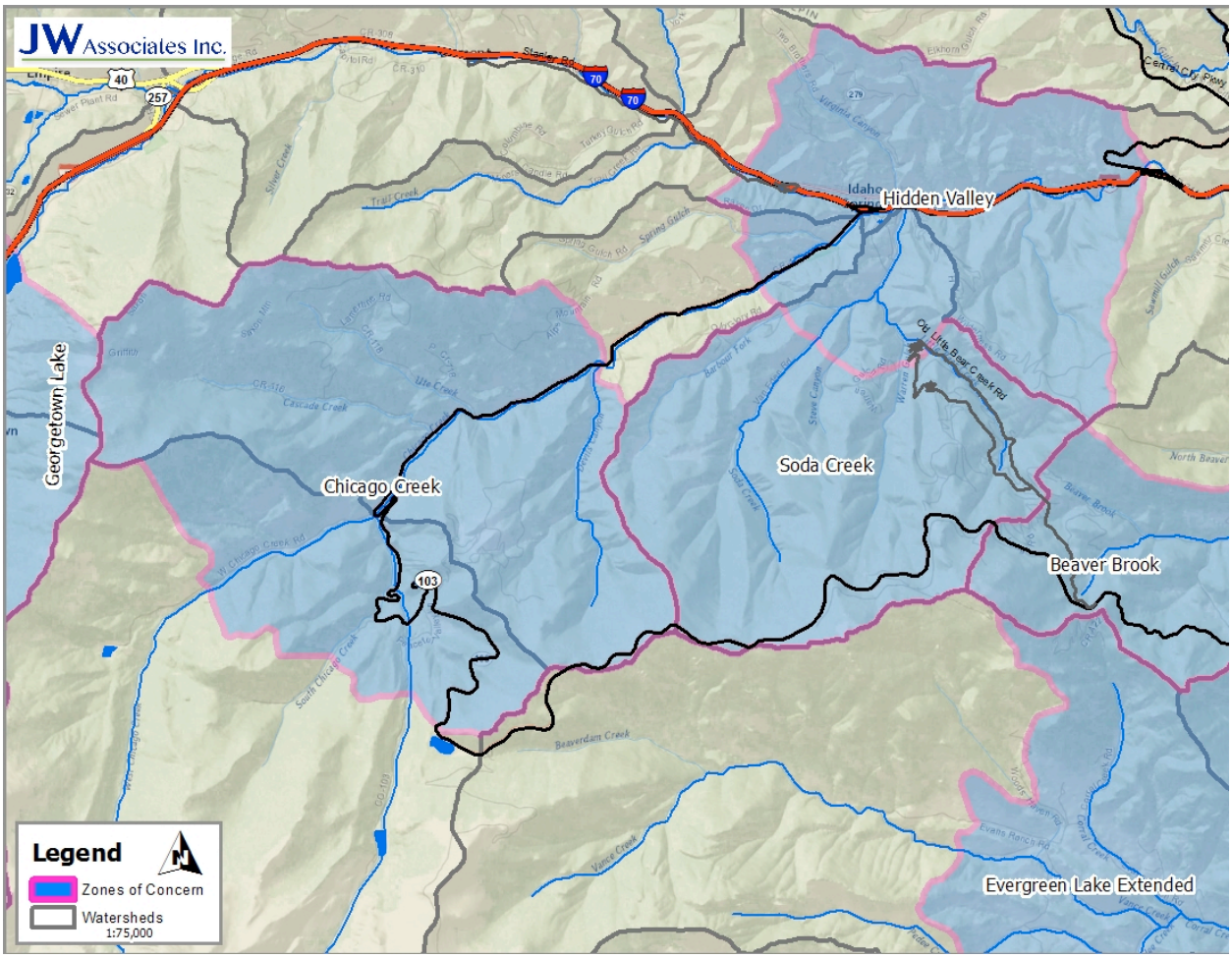


Figure 44. Chicago-Soda Creek ZoC Location

Chicago-Soda Creek ZoC Ownership

The majority of Chicago Creek ZoC is NFS lands (Figure 45), with some scattered private lands. The northern portion of Echo Lake Park extends in the southern part of the Chicago Creek ZoC, and the Alps Mountain Open Space extends into the northern portion. The Soda Creek ZoC is mostly NFS lands with some scattered pieces and some large blocks of private lands. The southern portion of the Hidden Valley ZoC is mostly NFS lands surrounded by private lands. The northern portion of the Hidden Valley ZoC is nearly all private with a portion of Central City lands in the eastern portion (Figure 45).

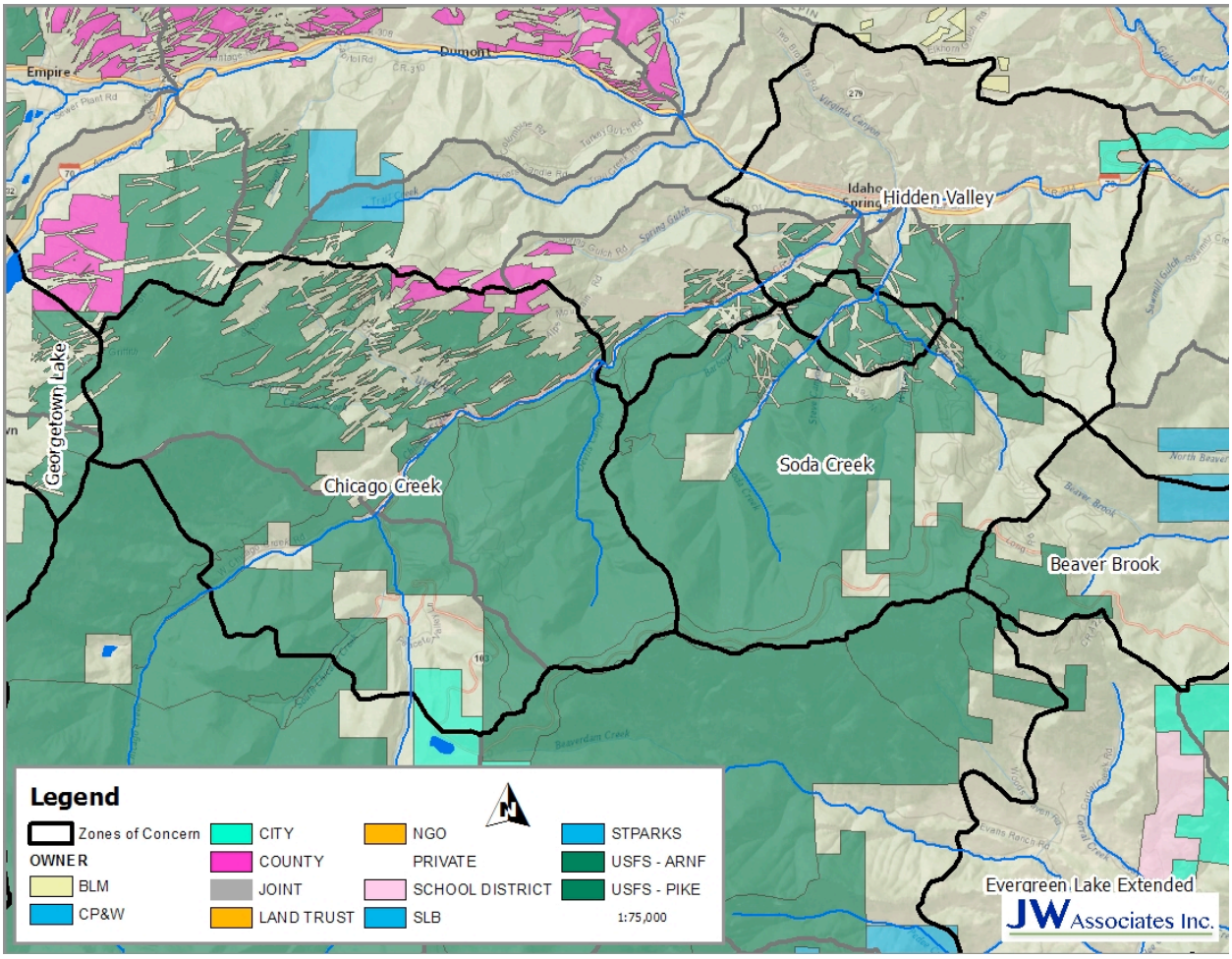


Figure 45. Chicago-Soda Creek ZoC Ownership

Chicago-Soda Creek ZoC Watershed Priority

The upper portion of the Chicago Creek ZoC is in the Headwaters West Chicago Creek watershed that is ranked as Green (Category 1) overall (Figure 46). Most of the Chicago Creek ZoC is in the Outlet Chicago Creek watershed that is ranked as Red (Category 5 - highest) overall, and for Wildfire Hazard, Flooding/Debris Flow Hazard, and Composite Hazard. The Soda Creek watershed is ranked as Red (Category 5 - highest) overall and for Wildfire Hazard, Flooding/Debris Flow Hazard, and Composite Hazard (Figure 46). The Hidden Valley ZoC is mostly within the City of Idaho Springs-Clear Creek watershed that is ranked as Red (Category 5 - highest) overall, and for Flooding/Debris Flow Hazard, and Composite Hazard. It is also ranked as Orange (Category 4) for Wildfire Hazard and Soil Erodibility. The upper portions of the Hidden Valley ZoC are part of the Headwaters West Chicago Creek and City of Idaho Springs-Clear Creek watersheds that are discussed above.

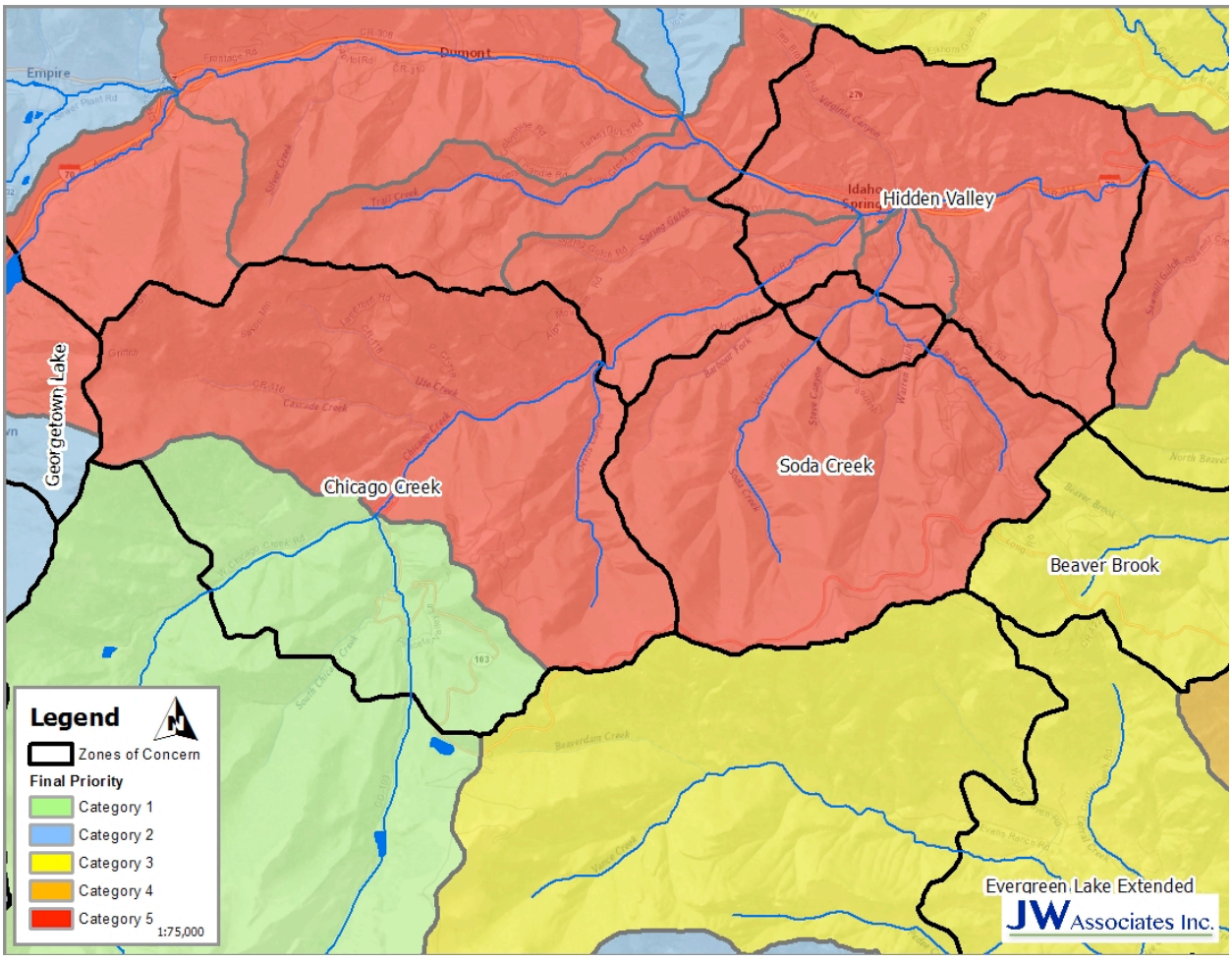


Figure 46. Chicago-Soda Creek ZoC Watershed Priority

Chicago-Soda Creek ZoC Slopes

The Chicago Creek ZoC has some large areas of steep slopes, mostly surrounding the main stream channels and scattered throughout the slopes between the streams (Figure 47). The Soda Creek ZoC also has large areas of steep slopes mostly surrounding the stream channels. The Hidden Valley ZoC also has steep slopes surrounding the main stream channels and scattered throughout, similar to the other ZoC in this area (Figure 47). There are some relatively large areas of shallower slopes in each of these three ZoC.

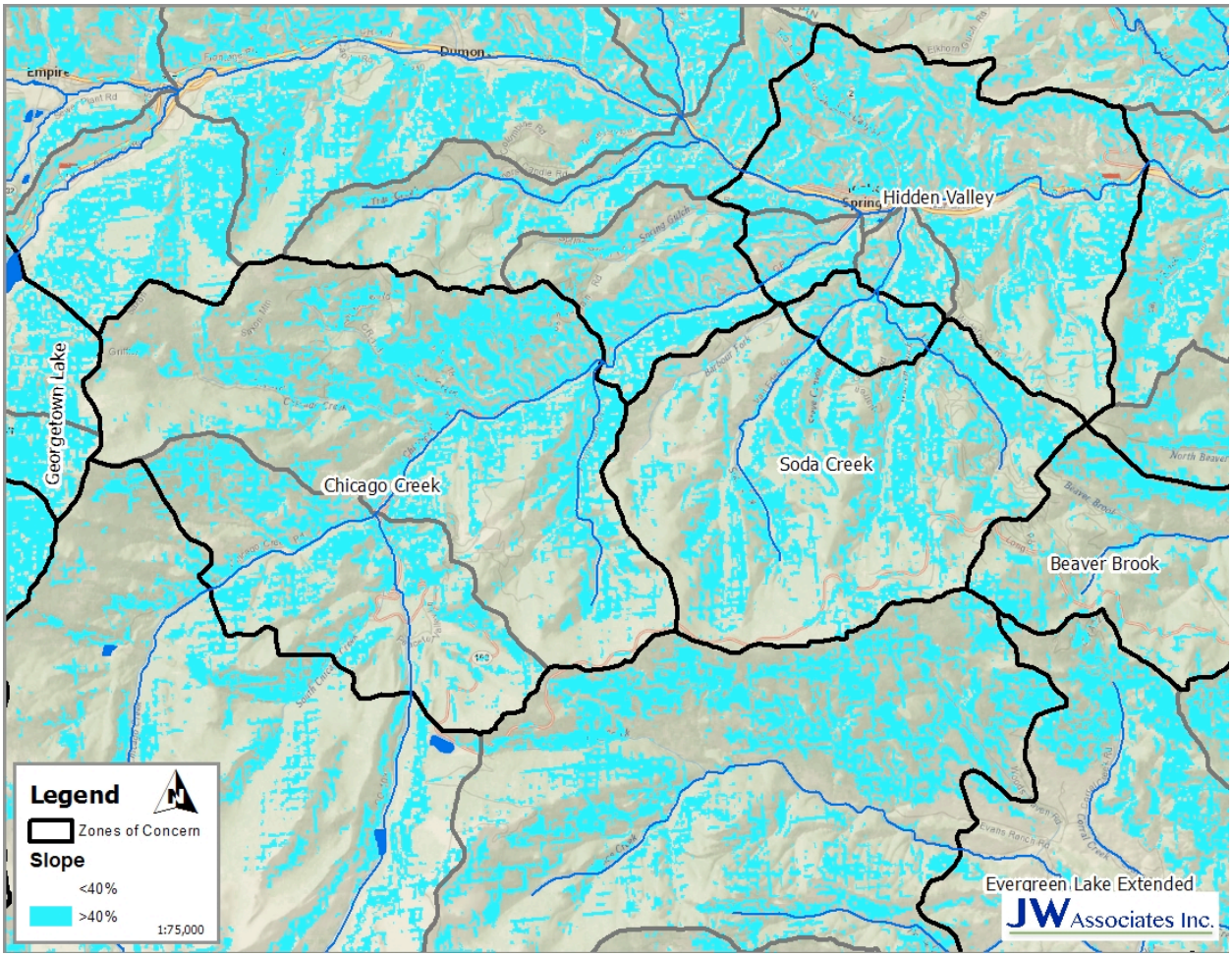


Figure 47. Chicago-Soda Creek ZoC Slope

Chicago-Soda Creek ZoC Special Management Areas

There are no special management areas in the Hidden Valley ZoC (Figure 48). The western portion of the Chicago Creek ZoC contains part of the Mount Evans Adjacent Roadless Area. Most of the Mount Evans Adjacent Roadless Area in the Chicago Creek ZoC is designated as Upper Tier. There is a small area of the Mount Evans Adjacent Roadless Area in the southern portion of the Soda Creek ZoC (Figure 48).

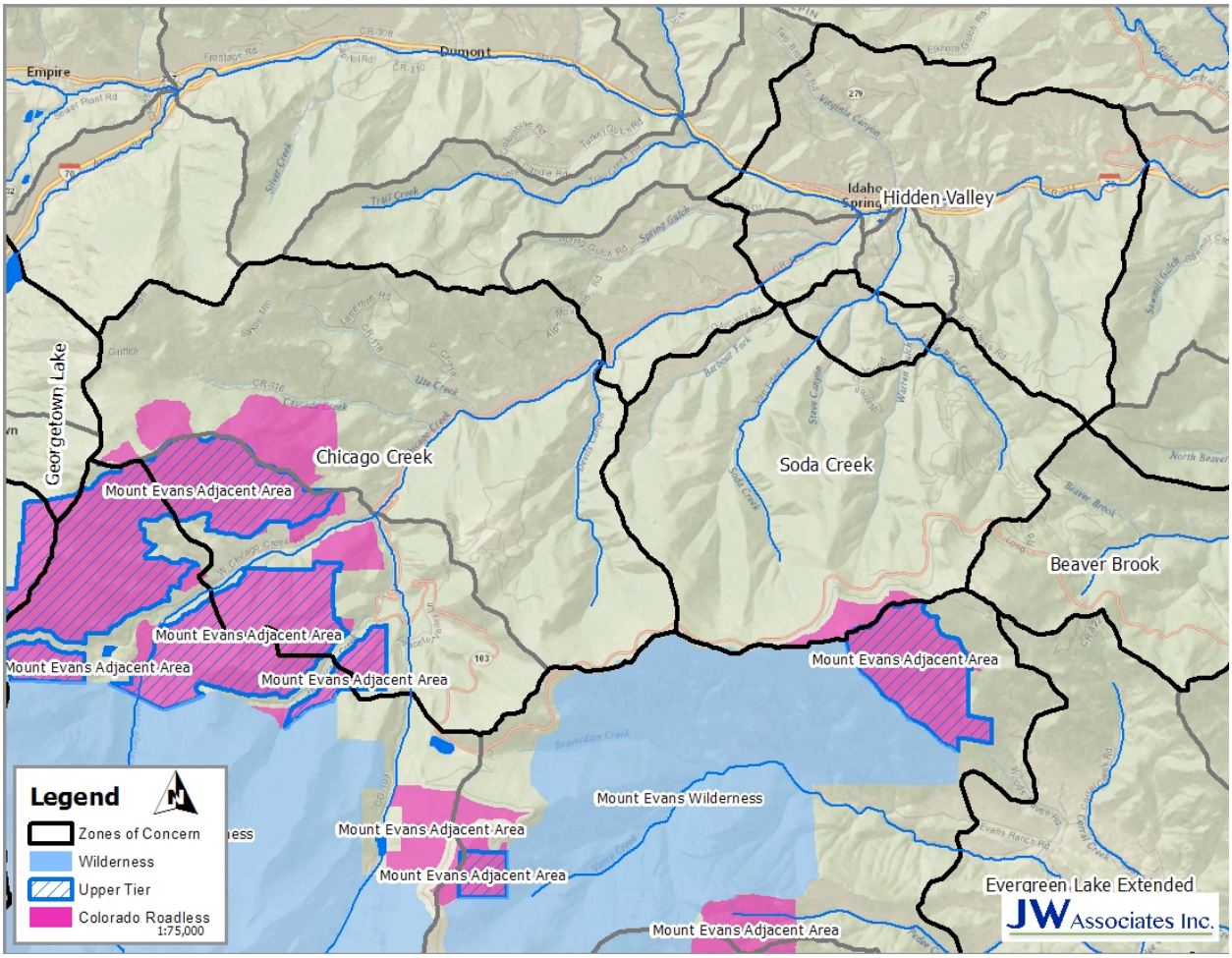


Figure 48. Chicago-Soda Creek ZoC Special Areas

Chicago-Soda Creek ZoC Vegetation

The Chicago Creek ZoC has a diversity of forested vegetation. It transitions from Douglas-fir and ponderosa pine at the lowest elevations to lodgepole pine and aspen at the middle elevations and finally to spruce-fir at the highest elevations (Figure 49). The Soda Creek ZoC is similar to the Chicago Creek ZoC but it has a larger more contiguous area of spruce-fir. The south-facing slopes in the Hidden Valley ZoC is dominated by ponderosa pine and Douglas-fir. The north-facing slopes have a mixture of Douglas-fir, aspen and lodgepole pine (Figure 49).

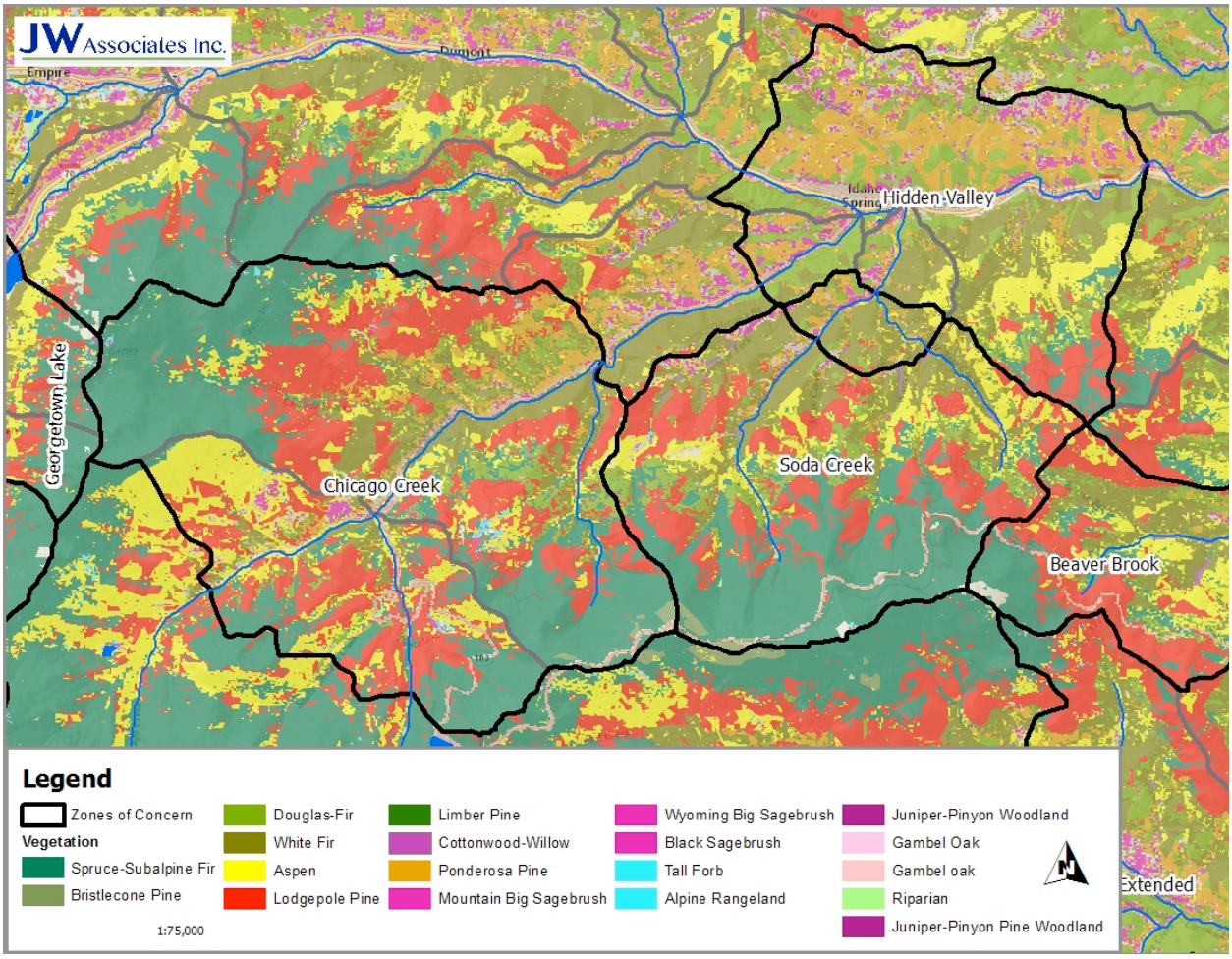


Figure 49. Chicago-Soda Creek ZoC Vegetation

Chicago-Soda Creek ZoC Access

All three of these ZoC have a number of existing roads that provide access to most forested areas (Figure 50), however, there are some areas that do not have access from existing roads.

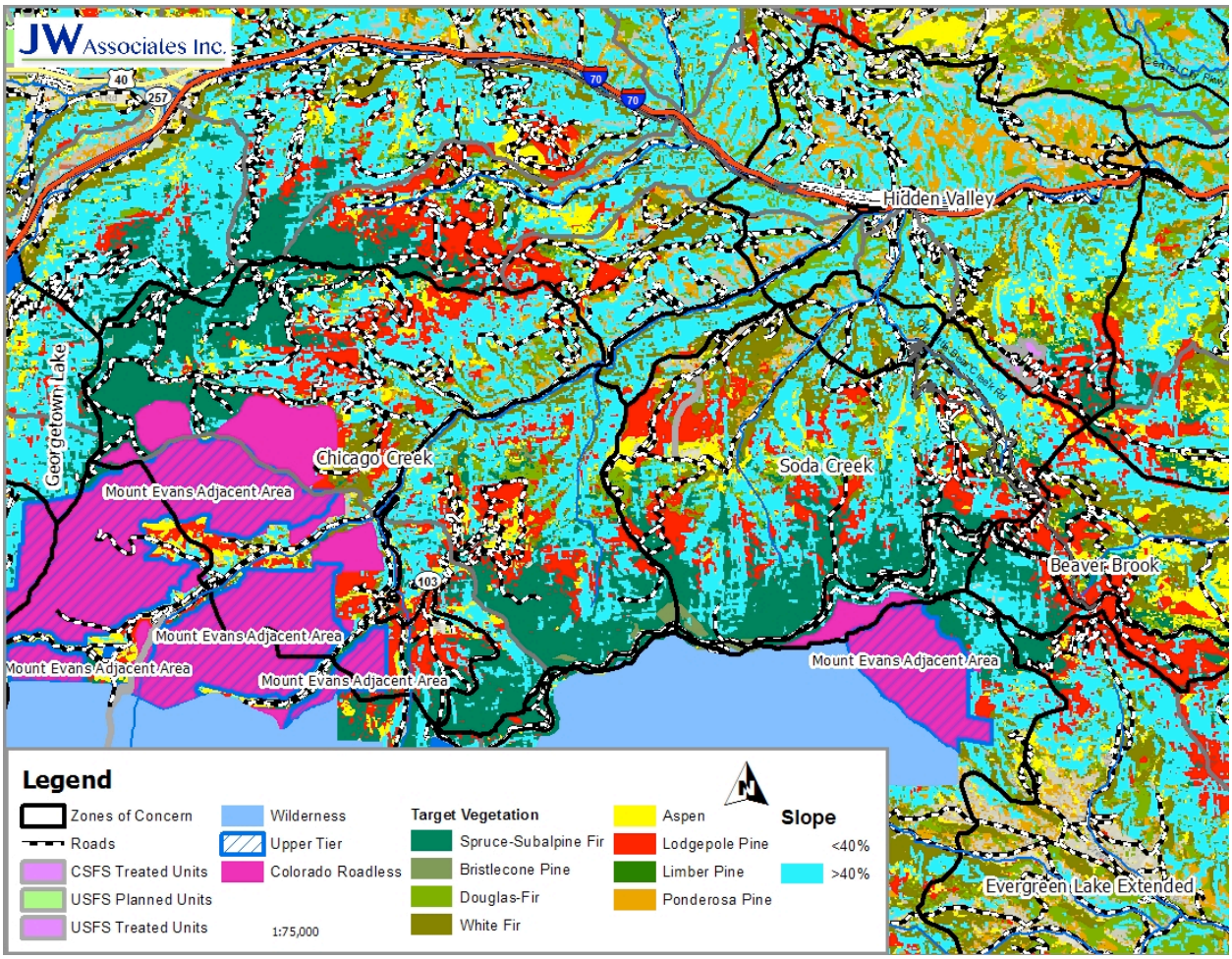
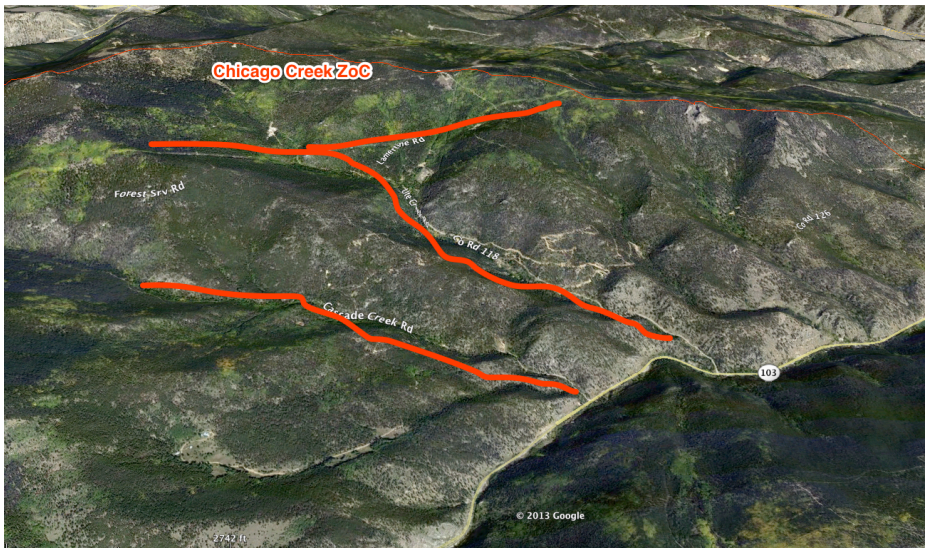


Figure 50. Chicago-Soda Creek ZoC Opportunities

Chicago-Soda Creek ZoC Opportunities

The Chicago Creek ZoC has several areas that present treatment opportunities. One of the opportunities for forest management is north of Chicago Creek where several existing roads provide access to a large area of lodgepole pine. The ownership is quite complicated in this area. Treatments should be directed at breaking up large areas of lodgepole pine and regenerating aspen where possible. Fuel breaks along these roads could also be explored as an option. Fuelbreaks and forest diversity treatments along Squaw Pass Road could also be explored.

The Soda Creek ZoC has several opportunities for forest treatments. The Squaw Pass Road could be used as the anchor for a fuelbreak that could extent back into the Chicago Creek ZoC. There are several roads lower in the ZoC that travel through blocks of lodgepole pine and aspen. These roads could be used to access treatments that would break up large areas of lodgepole pine and complete aspen enhancement treatments.



The Hidden Valley ZoC also has some opportunities for forest treatments. The forests on the north-facing slopes located south of Clear Creek are more dense and have some opportunities. The Hidden Wilderness Road is one example of an opportunity to explore. It appears that there might be an opportunity to enhance aspen through conifer removal in this area.

For all these ZoC the water providers should develop an information and education plan in conjunction with the US Forest Service to inform hikers, mountain bikers, users of off-road vehicles and other visitors to the wilderness and roadless areas about the importance of the area's watersheds and the danger of wildfire to water quality. They should also work with the US Forest Service to develop and implement fire management plans that could allow natural fires of lower intensities to burn within these watersheds to create greater diversity and reduce fuels.

Beaver Brook ZoC

The Beaver Brook ZoC is analyzed in this section (Figure 51). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

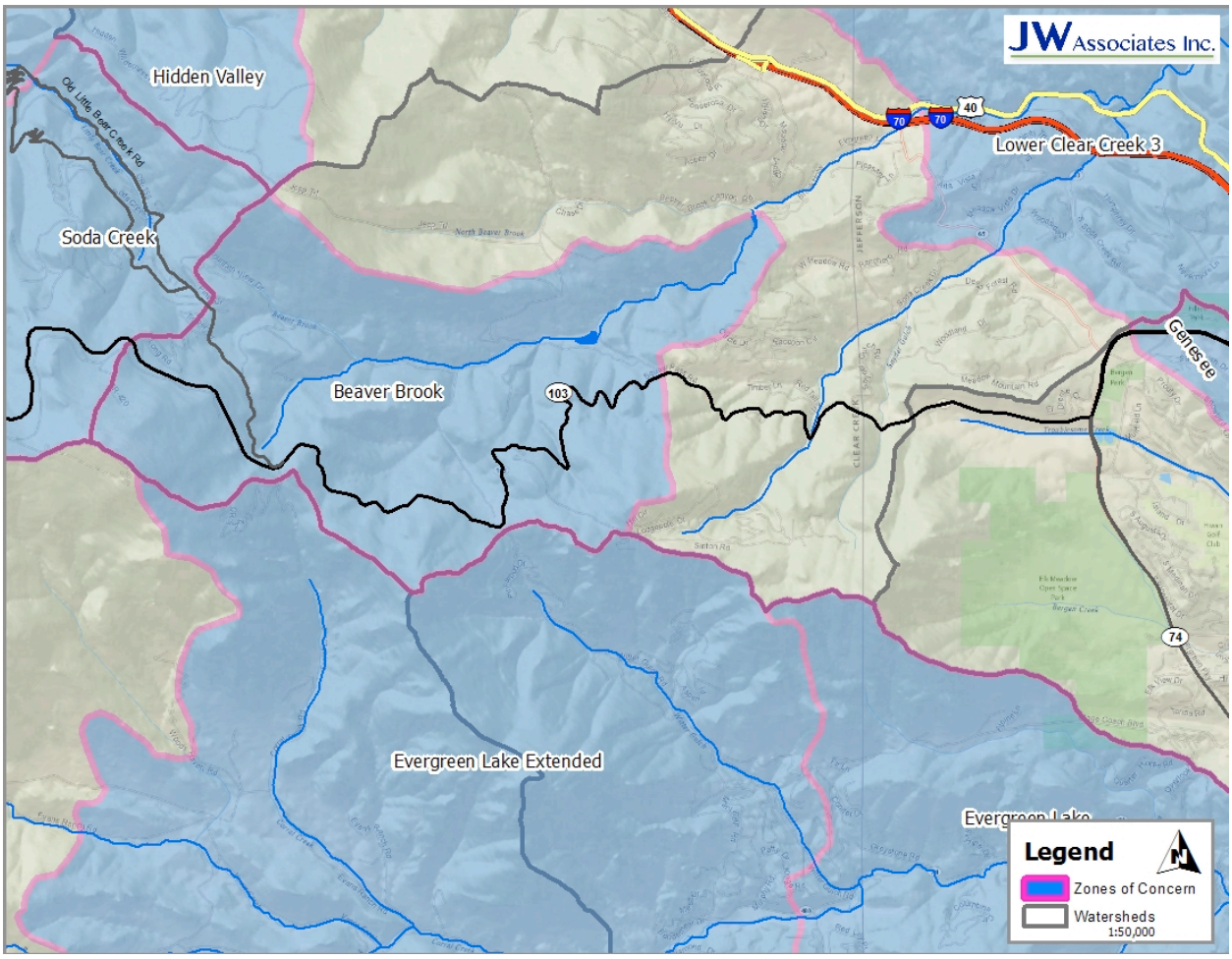


Figure 51. Beaver Brook ZoC Location

Beaver Brook Ownership

The Beaver Brook ZoC is mostly private lands with a large area in the Beaverbrook Watershed Open Space (Clear Creek County) and smaller areas of Colorado State Land Board and City of Golden lands (Figure 52).

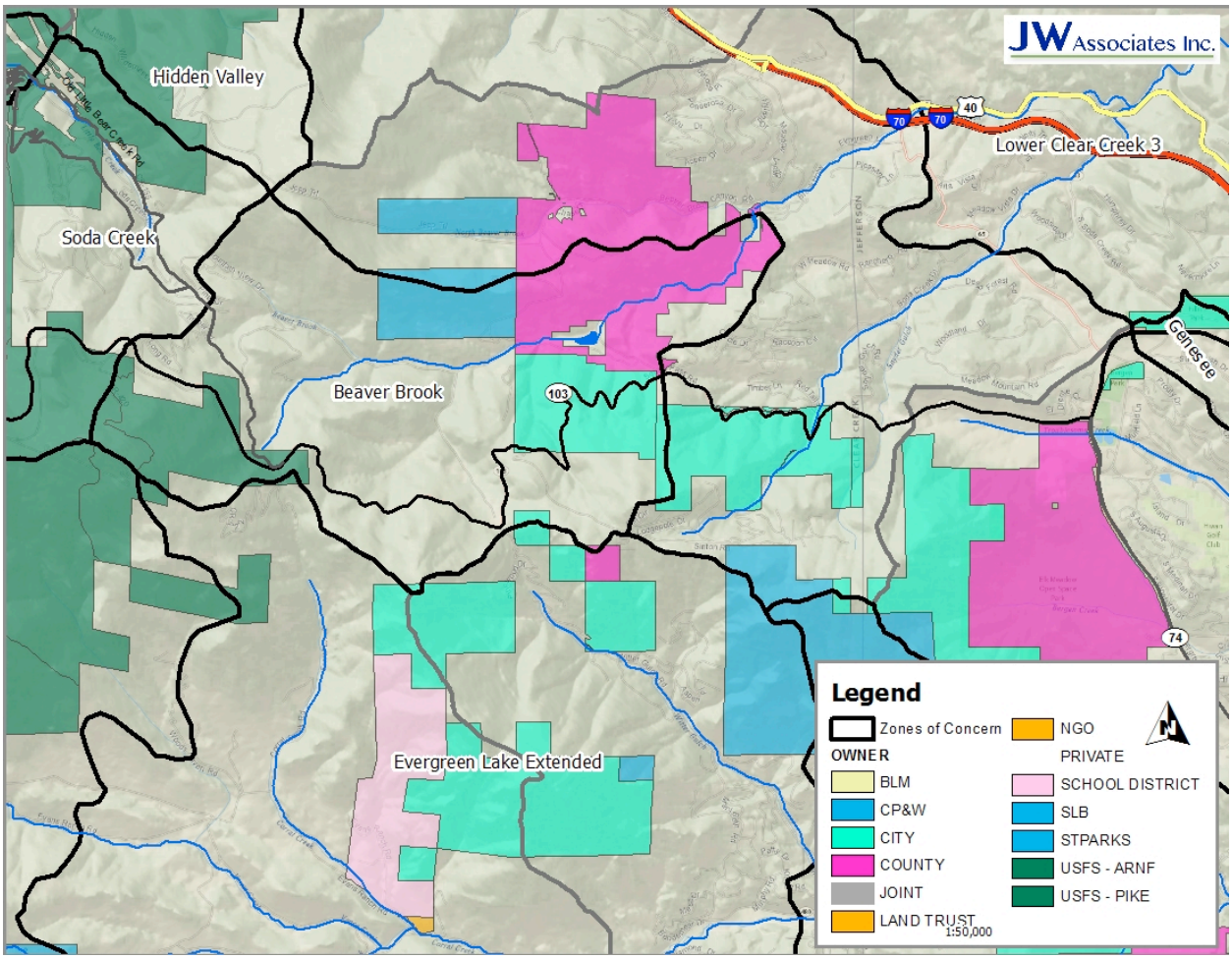


Figure 52. Beaver Brook ZoC Ownership

Beaver Brook Watershed Priority

The Beaver Brook-Clear Creek watershed is ranked as Yellow (Category 3) overall (Figure 53). It is also ranked as Orange (Category 4) for Flooding/Debris Flow Hazard.

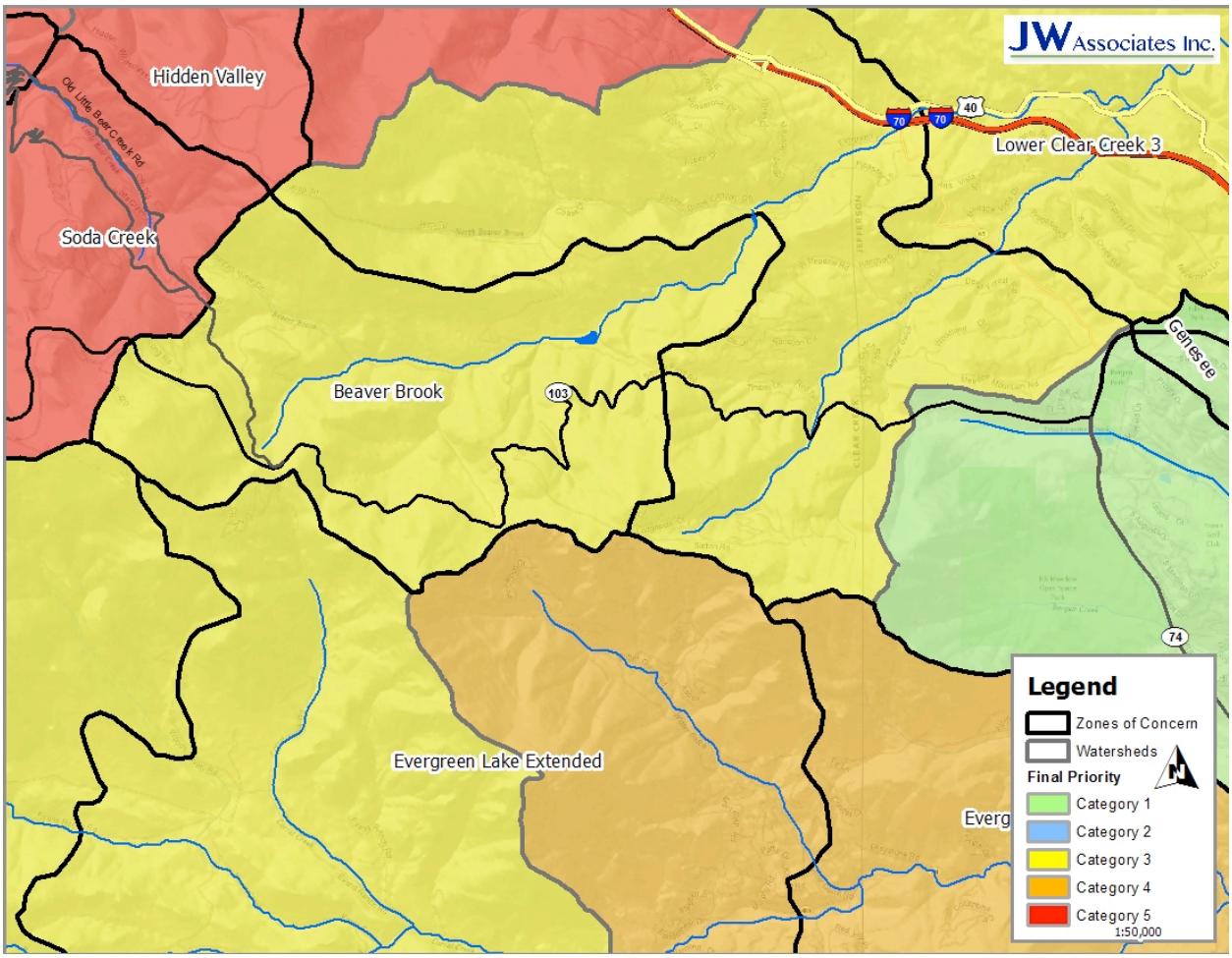


Figure 53. Beaver Brook ZoC Watershed Priority

Beaver Brook Slopes

The Beaver Brook ZoC has mostly shallow slopes (Figure 54), with a few areas of stepper slopes mostly on higher elevation south-facing slopes.

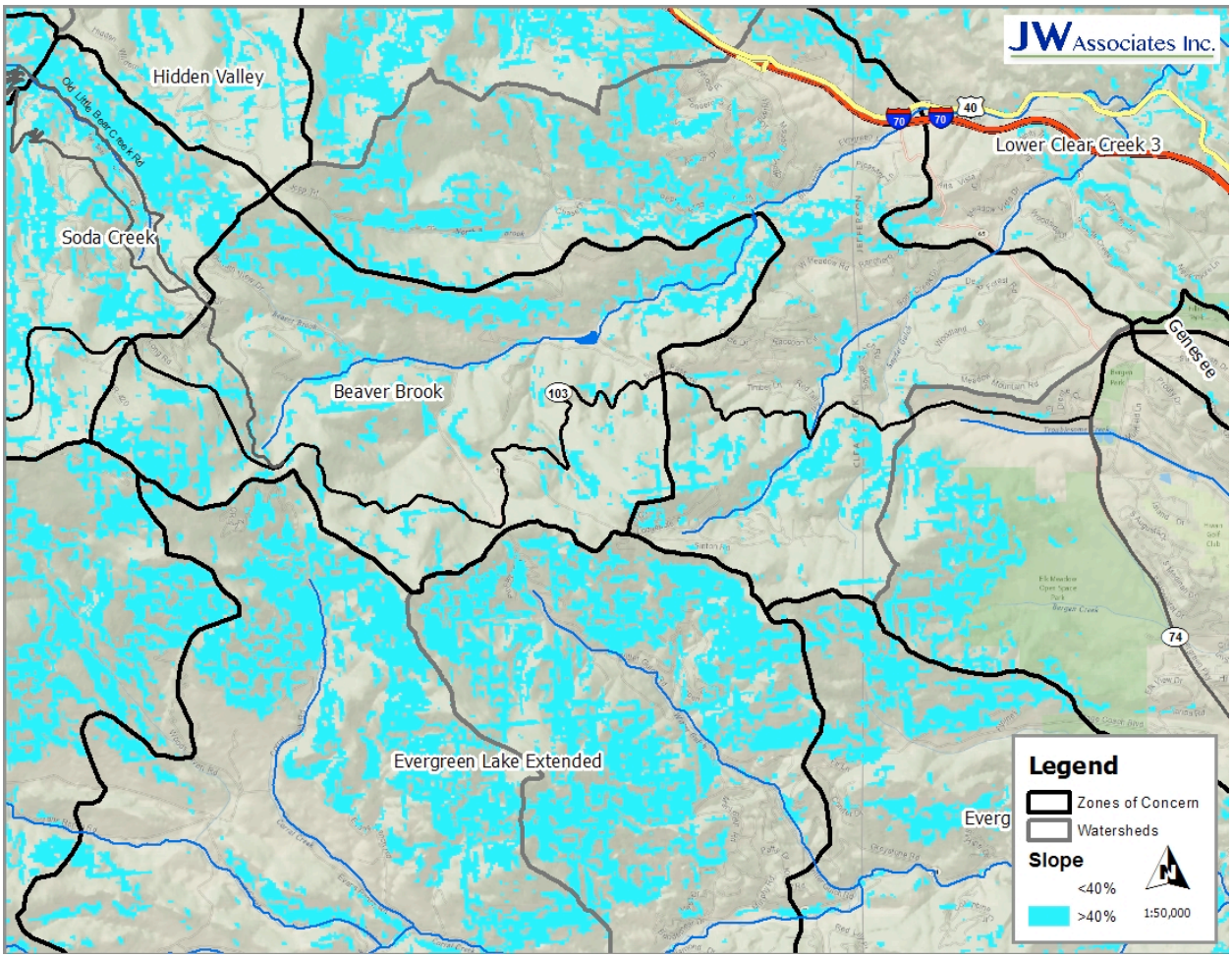


Figure 54. Beaver Brook ZoC Slope

Beaver Brook Special Management Areas

There are no special management areas in the Beaver Brook ZoC (Figure 55).

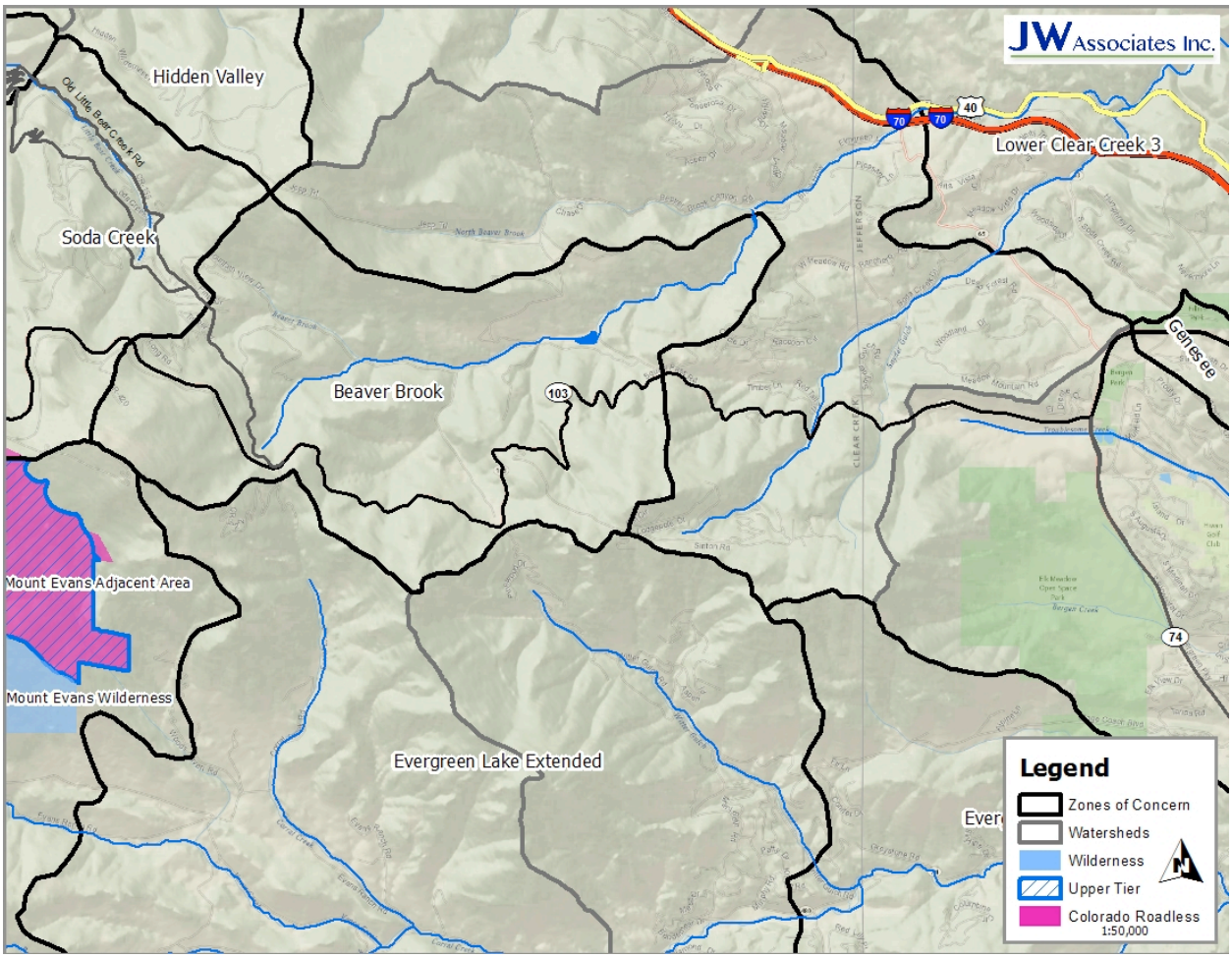


Figure 55. Beaver Brook ZoC Special Areas

Beaver Brook Vegetation

The Beaver Brook ZoC has a diverse forest with the lower elevations being Douglas-fir and some ponderosa pine, transitioning to aspen and then lodgepole pine at the highest elevations (Figure 56).

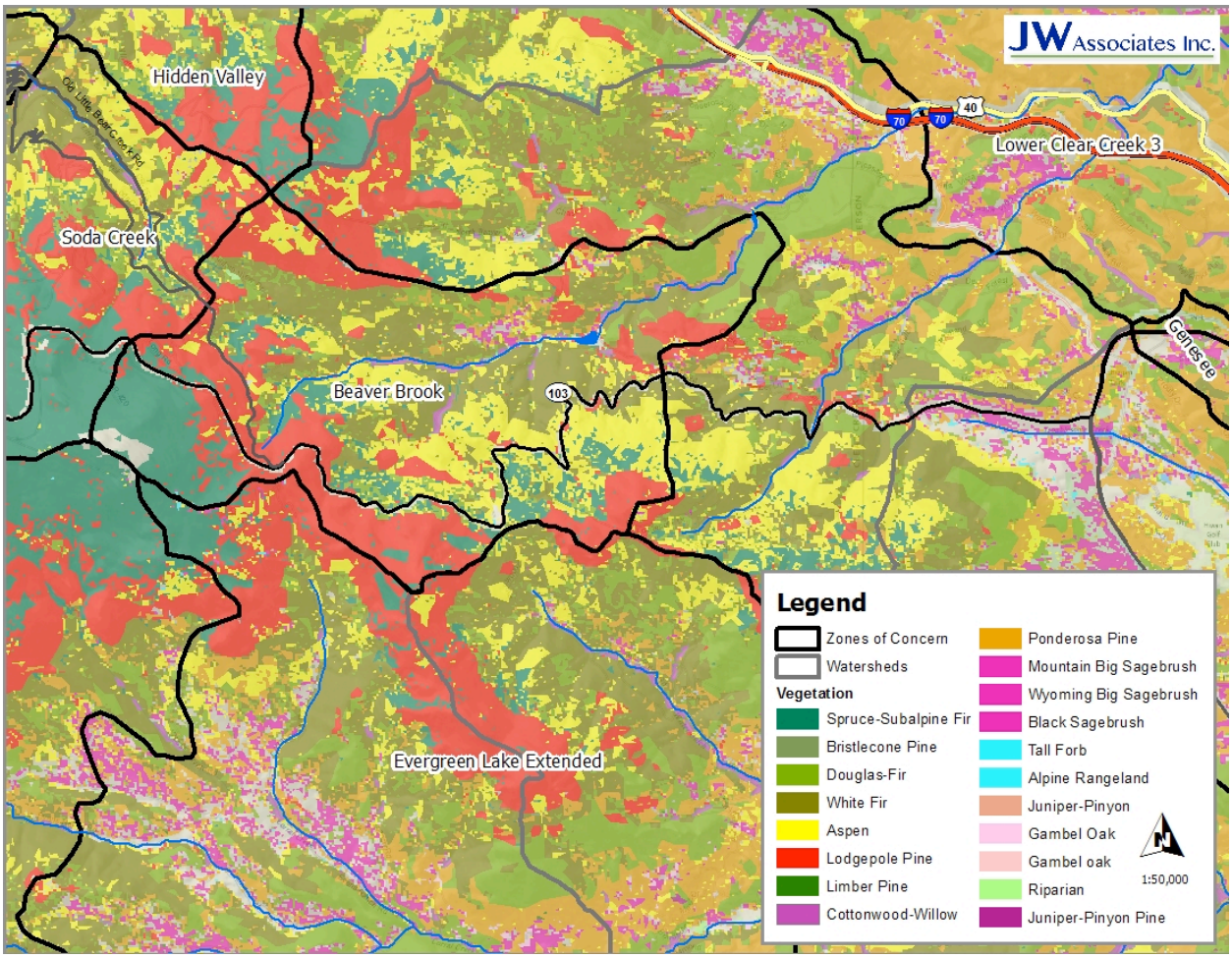


Figure 56. Beaver Brook ZoC Vegetation

Beaver Brook Access

Existing roads provide access to most of the forested areas in the Beaver Brook ZoC (Figure 57).

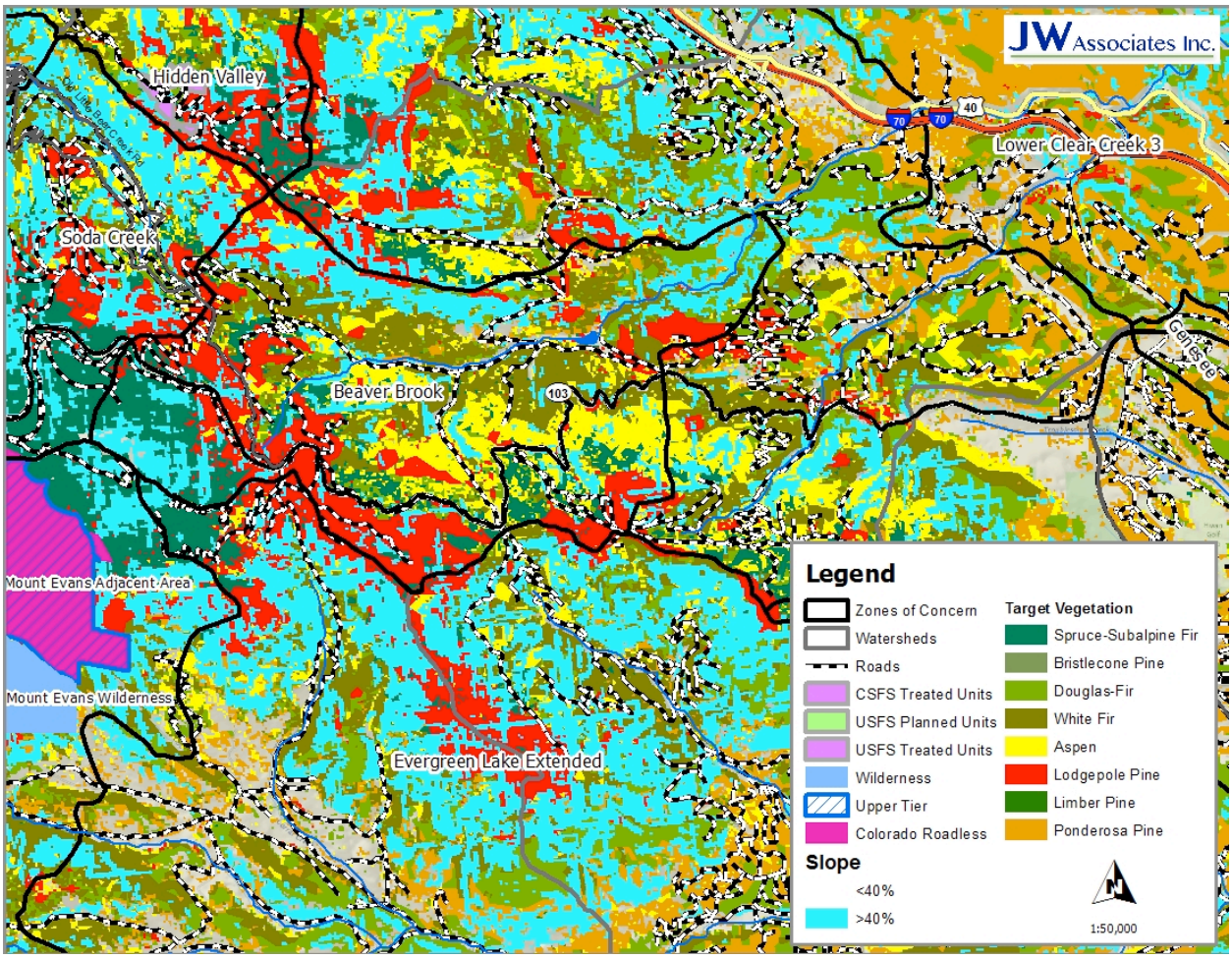


Figure 57. Beaver Brook ZoC Opportunities

Beaver Brook Opportunities

The Beaver Brook ZoC has some opportunities for forest management. Highway 103 provides good access across the southern portion of this ZoC. Where is crosses a large area of lodgepole pine, treatments should be directed at creating age class diversity and openings. In the areas with aspen, treatments should be directed at enhancing aspen. Lower in the ZoC, Douglas-fir should be thinned and removed from ponderosa pine stands where they are found. There are several pieces of open space and other ownerships in this ZoC. Water providers should work with Clear Creek County, State Land Board and the City of Golden.

North Clear Creek ZoC

This section discusses the North Clear Creek, Chase Gulch Reservoir, Missouri Creek Reservoir (Proposed), Quartz Valley Reservoir (Proposed), Pecks Gulch, Broomfield Gulch, and Miners Gulch ZoC because they are adjacent and/or overlapping (Figure 58). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

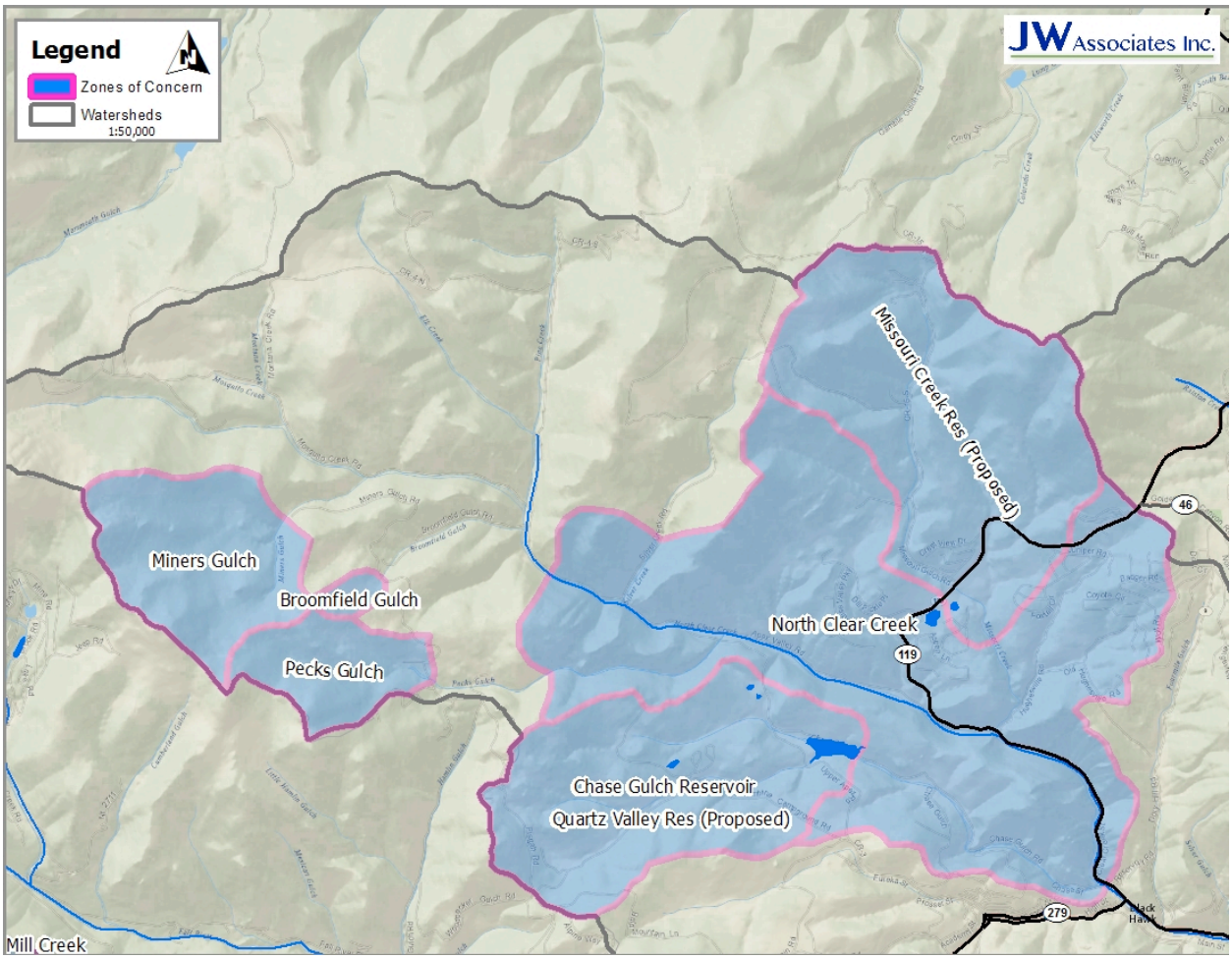


Figure 58. North Clear Creek ZoC Location

North Clear Creek Ownership

The upper portion of the North Clear Creek ZoC is NFS lands (Figure 59), with the rest of ZoC mostly in private ownership except for a parcel of Bureau of Land Management (BLM) lower in the ZoC. The Quartz Valley Reservoir ZoC has similar ownership patterns to the North Clear Creek ZoC. The Chase Gulch Reservoir ZoC is mostly NFS lands with private ownership in the lowest portion surrounding the reservoir. The Missouri Creek Reservoir ZoC has a similar ownership pattern to the Chase Gulch Reservoir ZoC. The Pecks Gulch, Broomfield Gulch and Miners Gulch ZoC all are mostly NFS lands with some private ownership scattered throughout the ZoC (Figure 59). The Miners Gulch ZoC also has a small piece of Colorado State Land Board land.

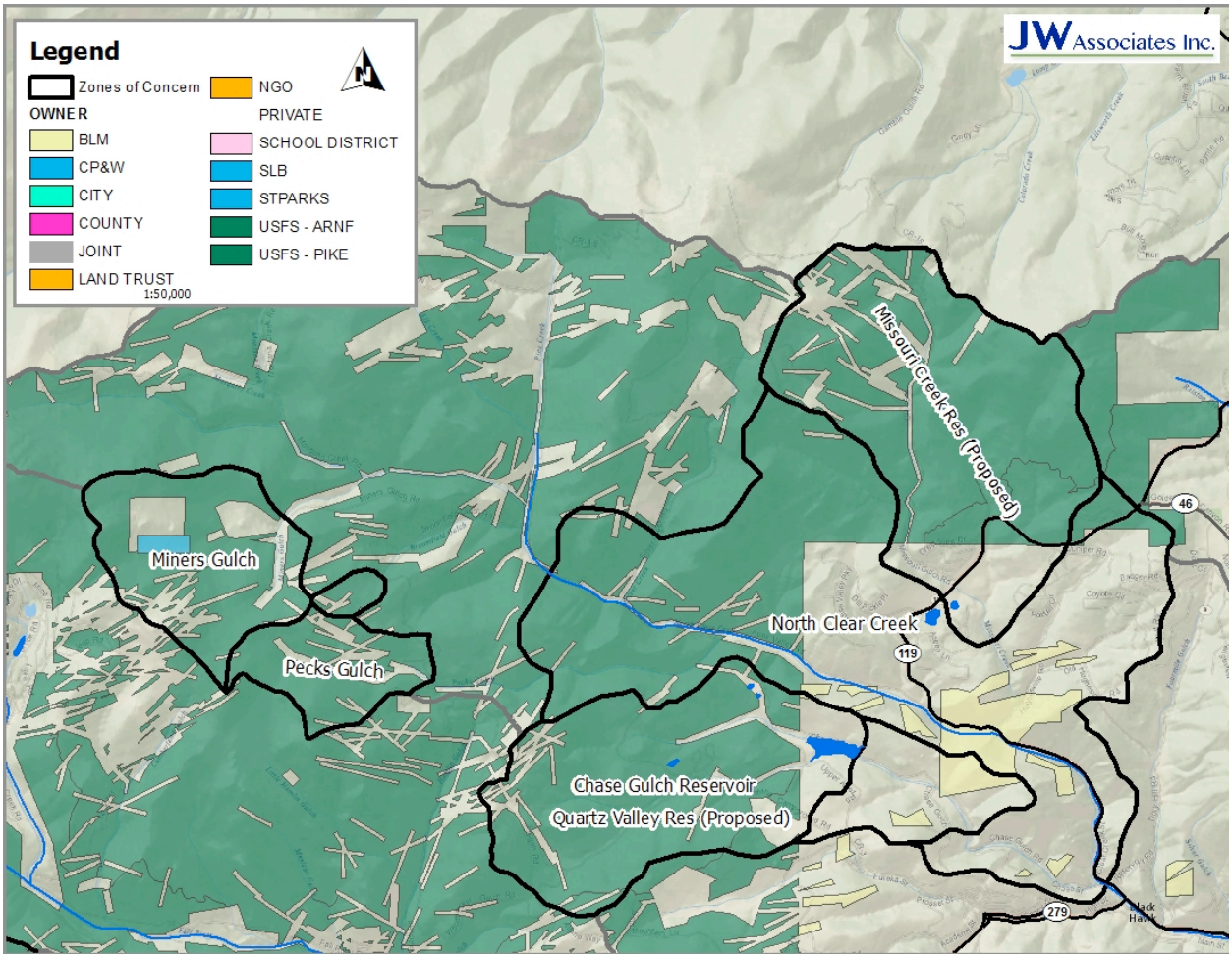


Figure 59. North Clear Creek ZoC Ownership

North Clear Creek Watershed Priority

All the ZoC are located within the North Clear Creek watershed (Figure 60) that is ranked Yellow overall (Category 3). It is also ranked Orange (Category 4) for Wildfire Hazard and Flooding/Debris Flow Hazard.

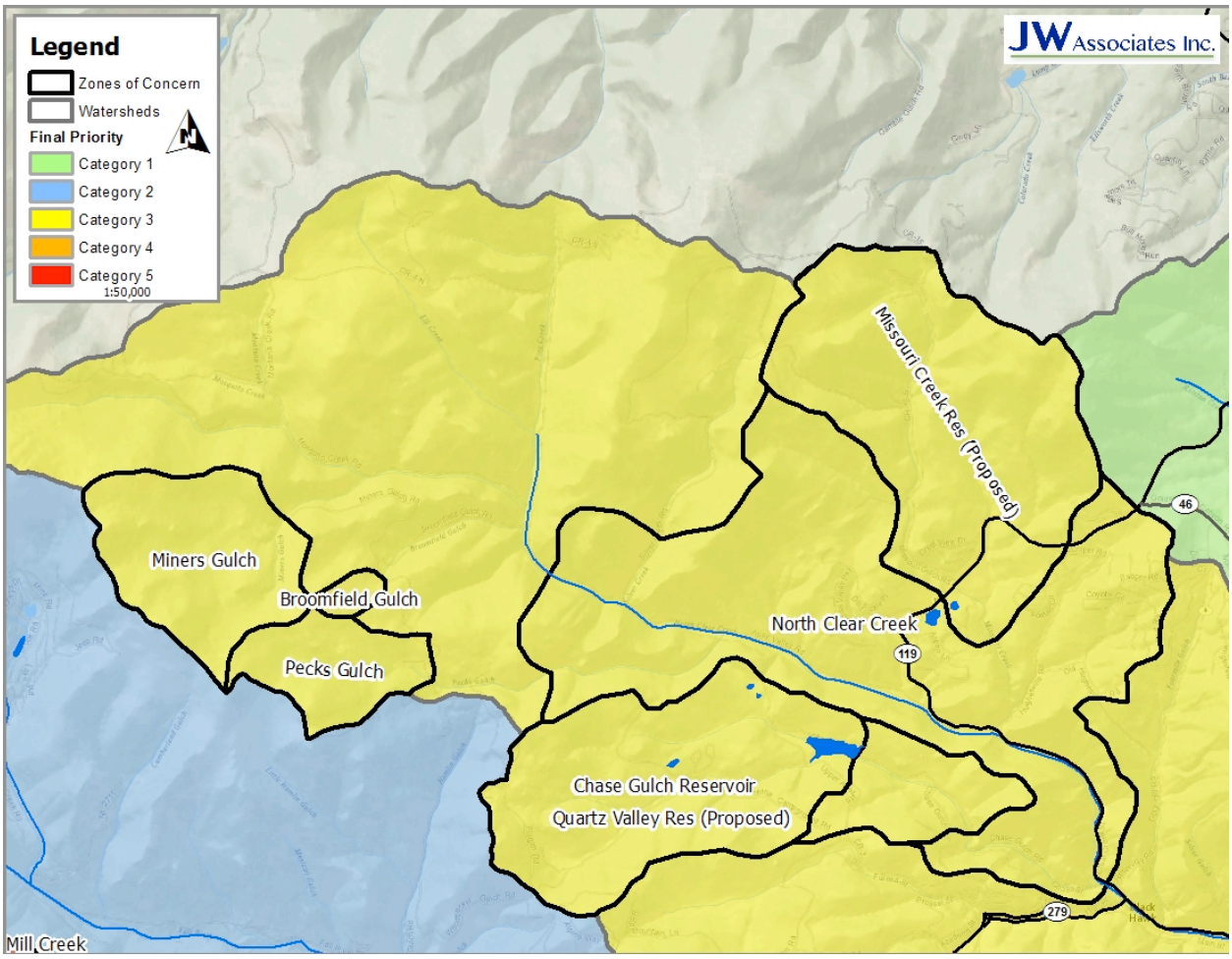


Figure 60. North Clear Creek ZoC Watershed Priority

North Clear Creek Slopes

The North Clear Creek ZoC has some areas of steep slopes surrounding the stream channels but there are large areas, primarily north of North Clear Creek that have shallower slopes (Figure 61). All other ZoC are mostly characterized by shallow slopes.

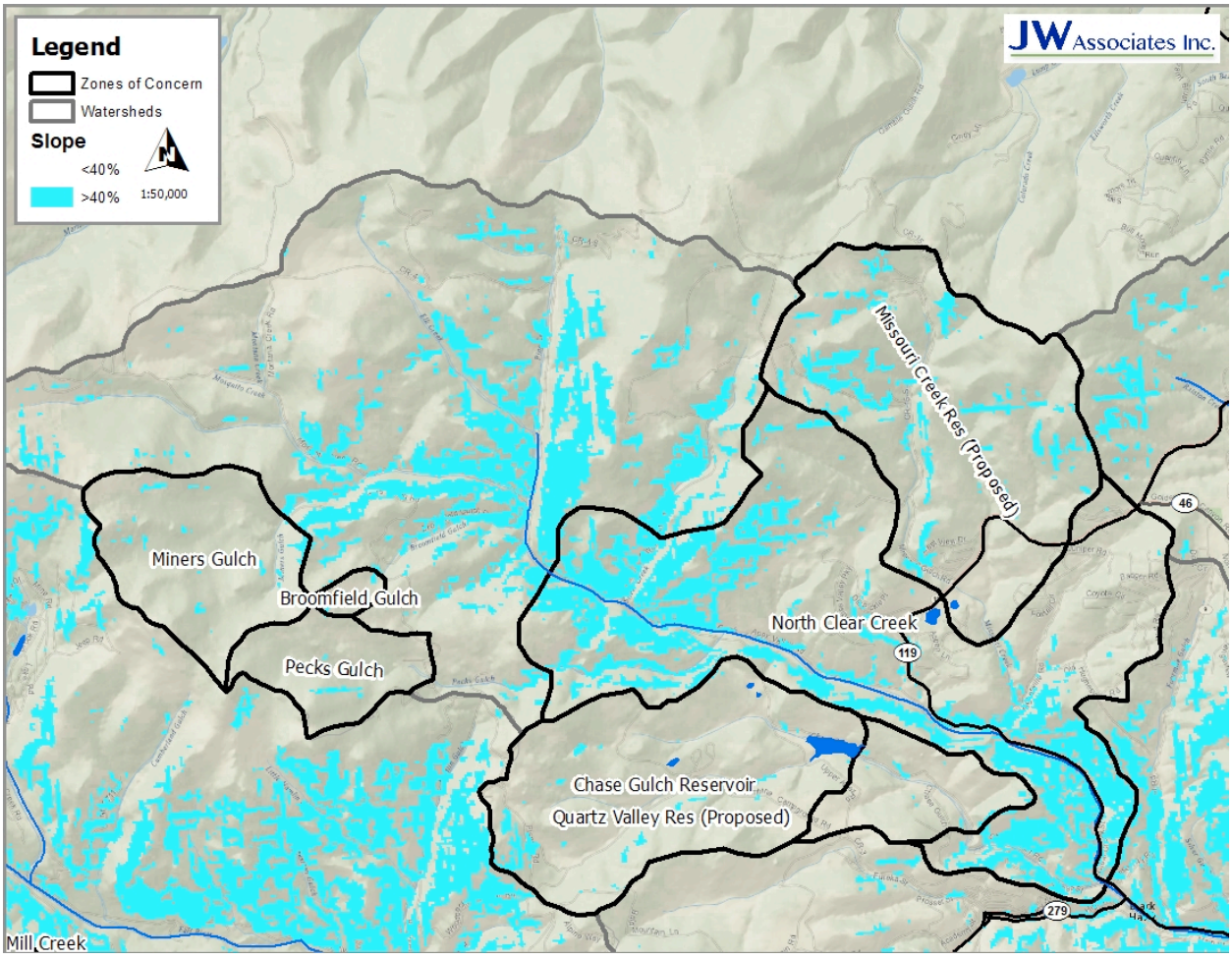


Figure 61. North Clear Creek ZoC Slope

North Clear Creek Special Management Areas

There are no special management areas in these ZoC (Figure 62).

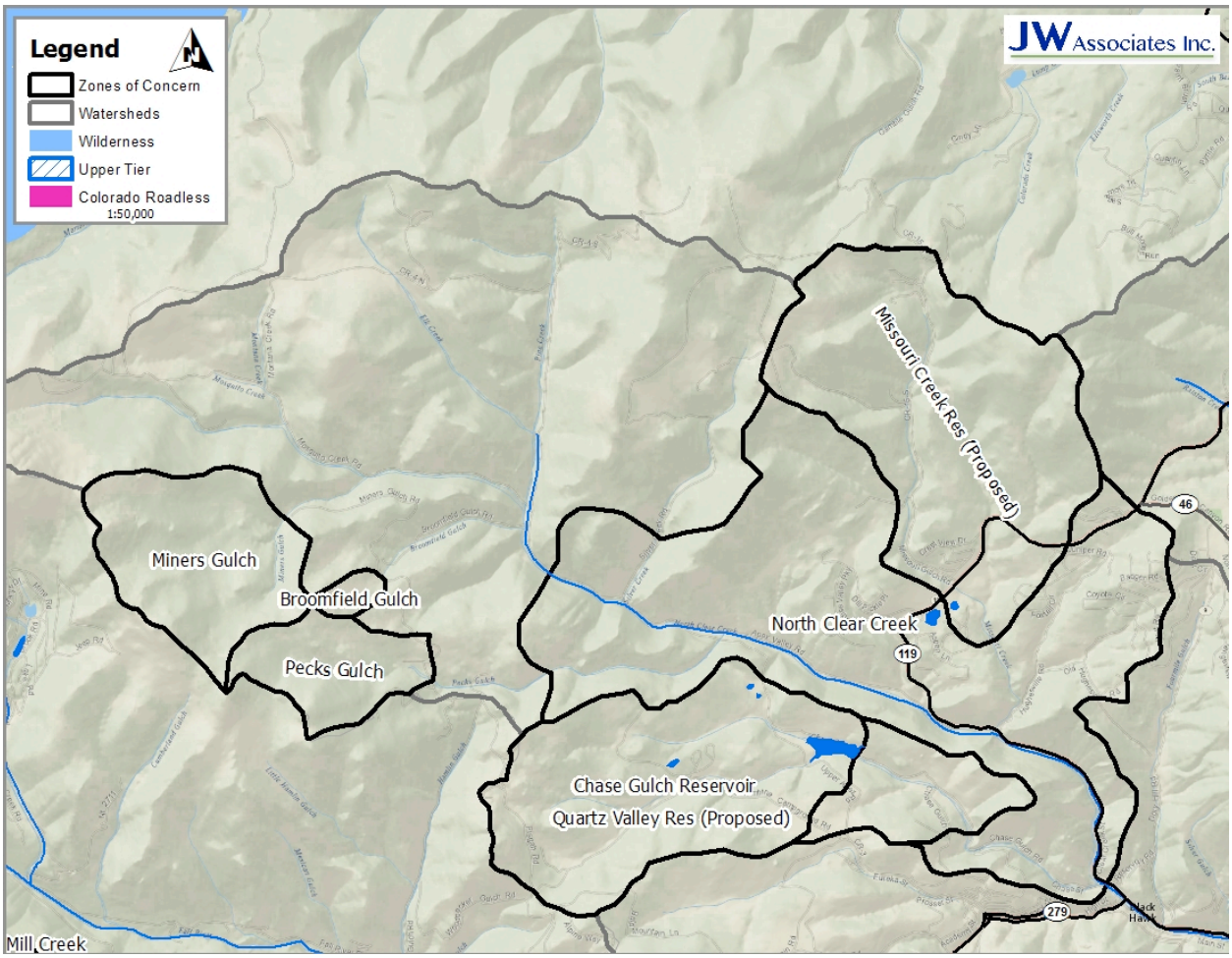


Figure 62. North Clear Creek ZoC Special Areas

North Clear Creek Vegetation

The North Clear Creek ZoC is a mixture of Dougals-fir and aspen lower in the ZoC and transitions to a mixture of lodgepole pine and aspen at higher elevations (Figure 63). The Missouri Gulch Reservoir ZoC has a mixture of Douglas-fir and lodgepole pine at the lowest elevations, but most of the ZoC is dominated by lodgepole pine. The Chase Gulch reservoir ZoC is characterized by a mixture of Douglas-fir and some sagebrush in the lower elevations with lodgepole pine and aspen dominated most of the higher elevations. The lower portions of the Quartz Valley Reservoir ZoC are mostly Douglas-fir on north-facing slopes with sagebrush on south-facing slopes. The upper portions of the Quartz Valley Reservoir ZoC overlap with the Chase Gulch Reservoir ZoC. The Miners Gulch ZoC is almost entirely spruce-fir forest. The upper portions of Pecks Gulch ZoC are spruce-fir with the lower portions being a combination of lodgepole pine and aspen. The Broomfield Gulch ZoC is a mixture of lodgepole pine and aspen (Figure 63).

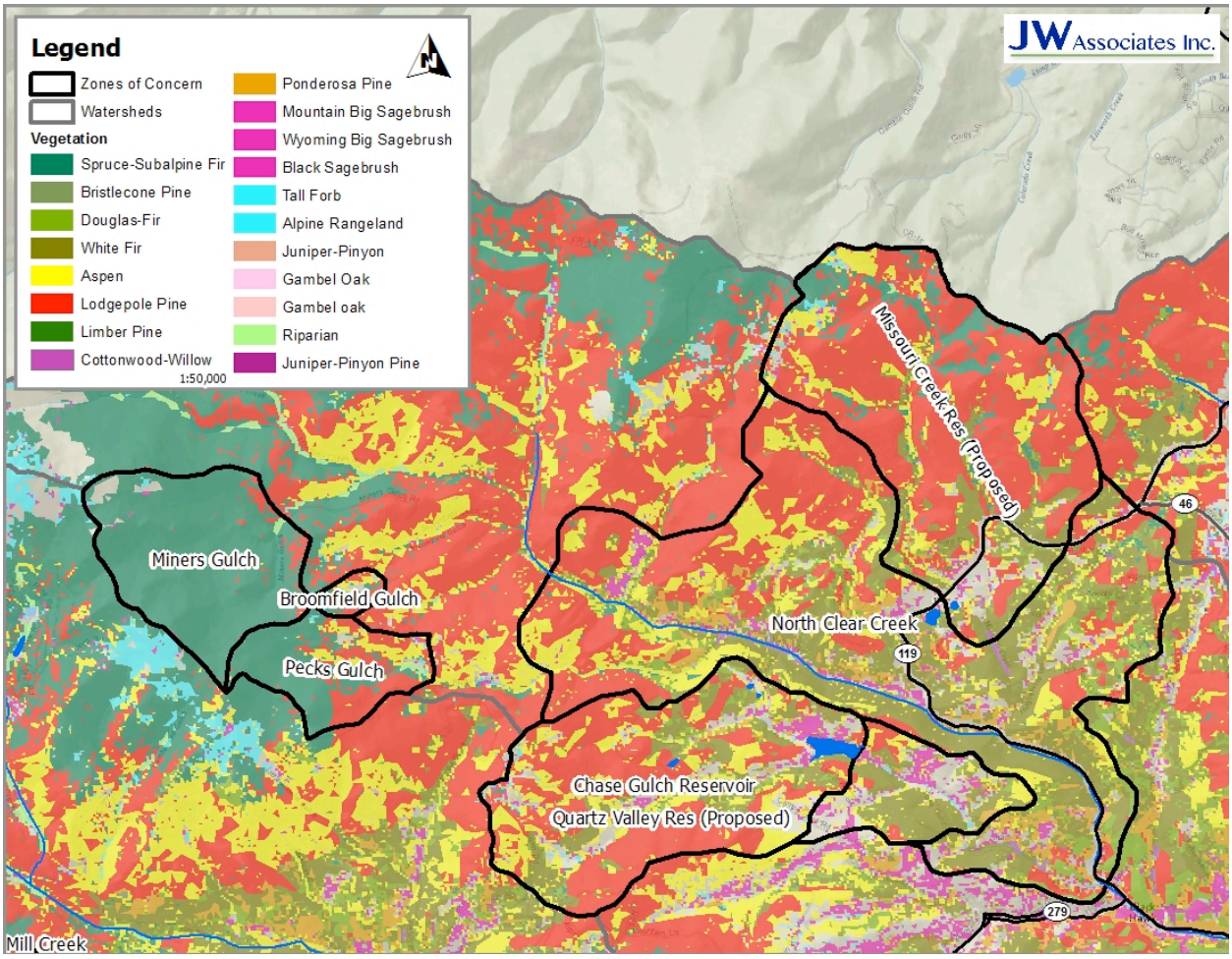


Figure 63. North Clear Creek ZoC Vegetation

North Clear Creek Access

Most of these ZoC have some existing road access (Figure 64). One of the biggest pieces without access is the area north of North Clear Creek in the North Clear Creek ZoC.

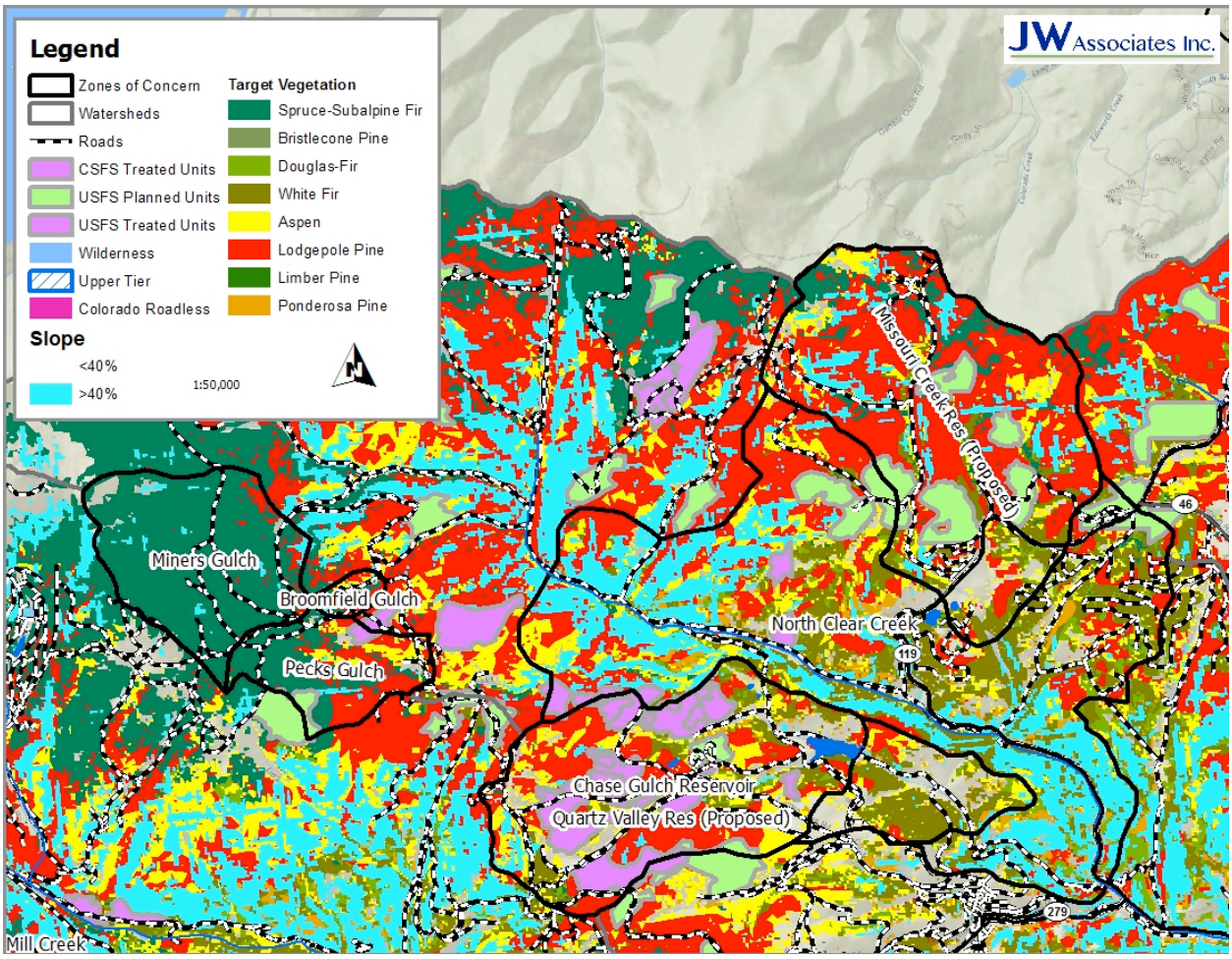


Figure 64. North Clear Creek ZoC Opportunities

North Clear Creek Opportunities

The Chase Gulch and Quartz Valley Reservoir (Proposed) ZoC overlap and are discussed together. A number of treatments have been completed and more are planned in these ZoC. This ZoC should be reviewed in more detail to determine if additional treatments are needed. Coordination with the US Forest Service on the treatments that are planned and not yet completed would be beneficial in getting them accomplished. Also coordination with the US Forest Service and the Colorado State Forest Service on any followup or maintenance treatments would provide the agencies direction on the importance of those treatments. Additional treatments could be explored along the road to the campground that could compliment the previous treatments and create more forest diversity in this area.

The North Clear Creek ZoC has a number of opportunities. There are many private roads that could be used as fuelbreaks, but the water providers would have to work with the landowners which would add some difficulty to those treatments. There are some planned US Forest Service units in the northwestern portion of this ZoC that could provide some watershed protection benefits. The treatments should be designed to breakup large areas of even-aged lodgepole pine and enhance aspen where possible.

The Missouri Creek Reservoir (Proposed) has some opportunities. This ZoC has some US Forest Service planned treatments that could provide watershed protection benefits. The treatments should be designed to breakup large areas of even-aged lodgepole pine and enhance aspen where possible. The water providers should work with the US Forest Service to make sure that these treatments are implemented and have the maximum possible watershed protection benefit. There might be more treatments that could be accomplished in the upper portion of this ZoC in conjunction with the US Forest Service planned units.

The Miners Gulch ZoC is basically all spruce-fir forest. There are some opportunities along existing roads to construct fuel breaks along the roads. These fuel breaks would function as places that would reduce the fire intensity and provide a safer place for suppression forces to work.

The Broomfield Gulch ZoC is very small and appears to have a relatively open forest. There was a US Forest Service treatment completed just south of this ZoC. The area along the road is very open and already serves as a fuel break.

The Pecks Gulch ZoC has limited road access, however there is a recently completed US Forest Service treatment in the lowest elevations of this ZoC. There may be some opportunities to complete some additional treatments in lodgepole pine and aspen. The treatments should be designed to enhance aspen through conifer removal or regeneration and increasing age-class diversity of lodgepole pine.

For all these ZoC the water providers should develop an information and education plan in conjunction with the US Forest Service to inform hikers, mountain bikers, users of off-road vehicles and other visitors to the wilderness and roadless areas about the importance of the area's watersheds and the danger of wildfire to water quality. They should also work with the US Forest Service to develop and implement fire management plans that could allow natural fires of lower intensities to burn within these watersheds to create greater diversity and reduce fuels.

Ralston Reservoir ZoC

This section discusses the Ralston Reservoir and Ralston Reservoir Extended ZoC because they are adjacent (Figure 65). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

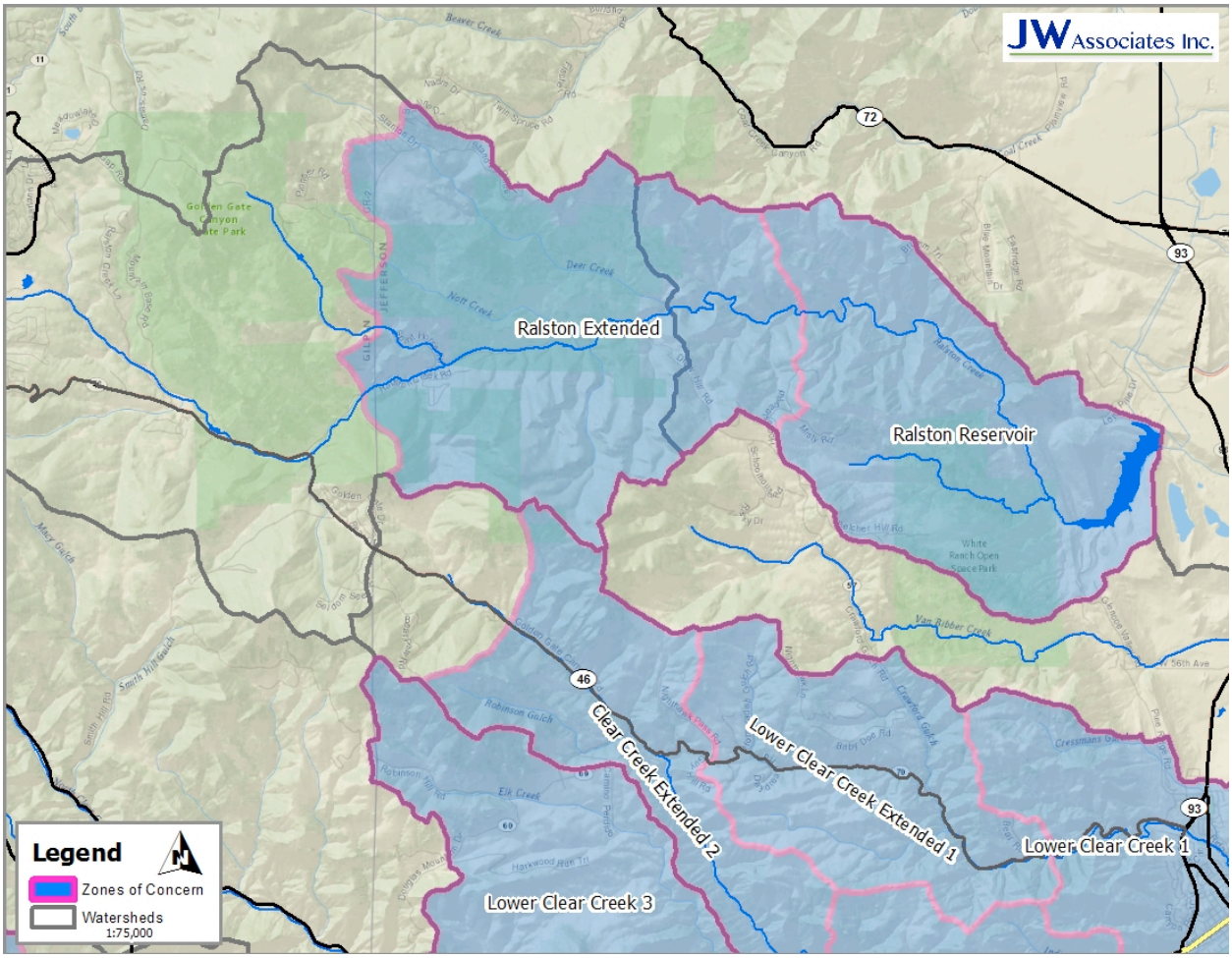


Figure 65. Ralston Reservoir ZoC Location

Ralston Reservoir Ownership

White Ranch Park occupies a large portion of the Ralston Reservoir ZoC (Figure 66) along with two other pieces of Jefferson County Open Space. Two state owned areas, Ralston Creek Special Wildlife Area and Golden Gate Canyon State Park, occupy most of the Ralston Reservoir Extended ZoC (Figure 66).

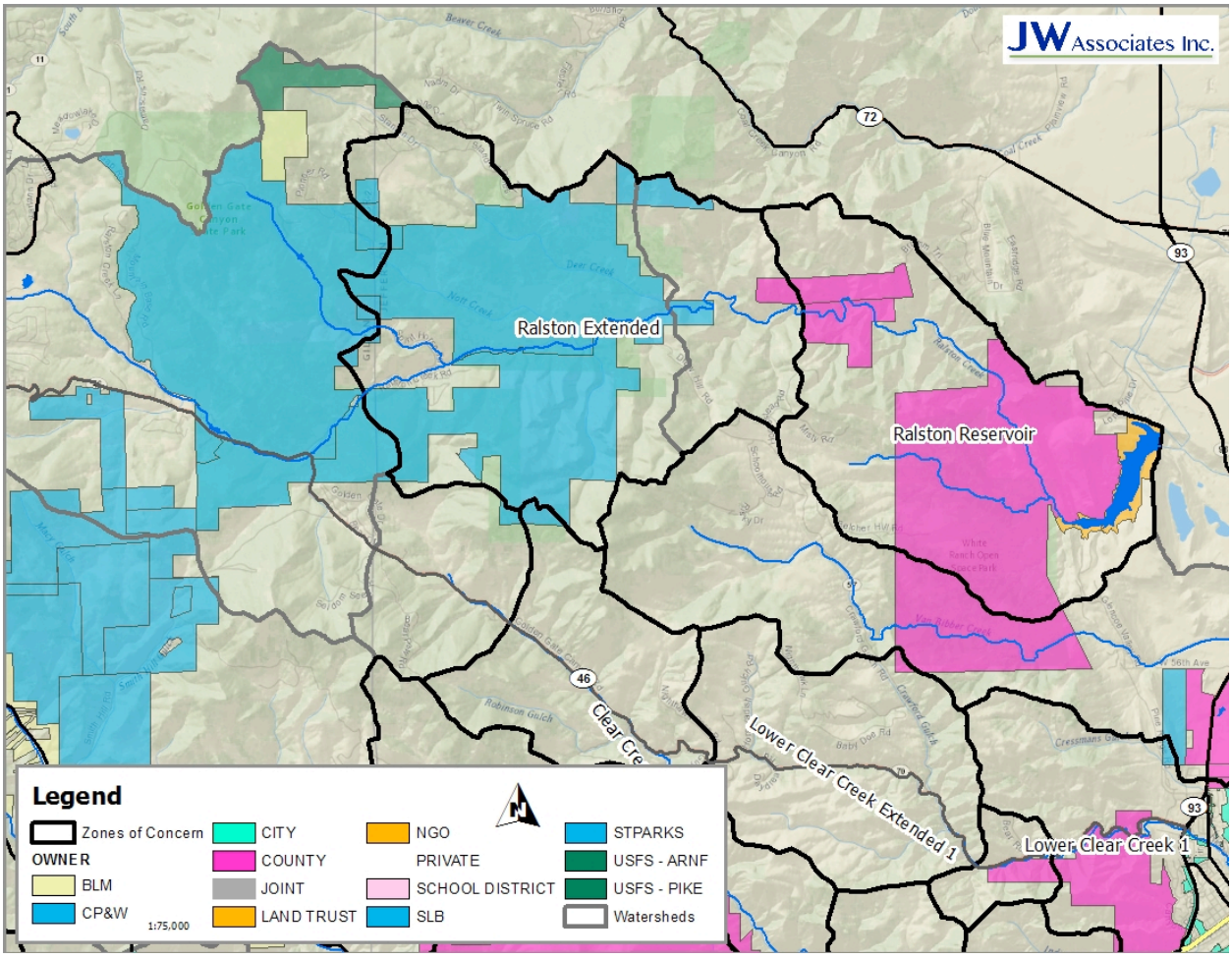


Figure 66. Ralston Reservoir ZoC Ownership

Ralston Reservoir Watershed Priority

The Ralston Reservoir ZoC and the lower portion of the Ralston Reservoir Extended ZoC are within the MIddle Ralston Creek watershed (Figure 67) that is ranked Blue overall (Category 2). The remainder of the Ralston Reservoir Extended ZoC is within the Upper Ralston Creek watershed that is ranked Green (Category 1 - lowest) overall.

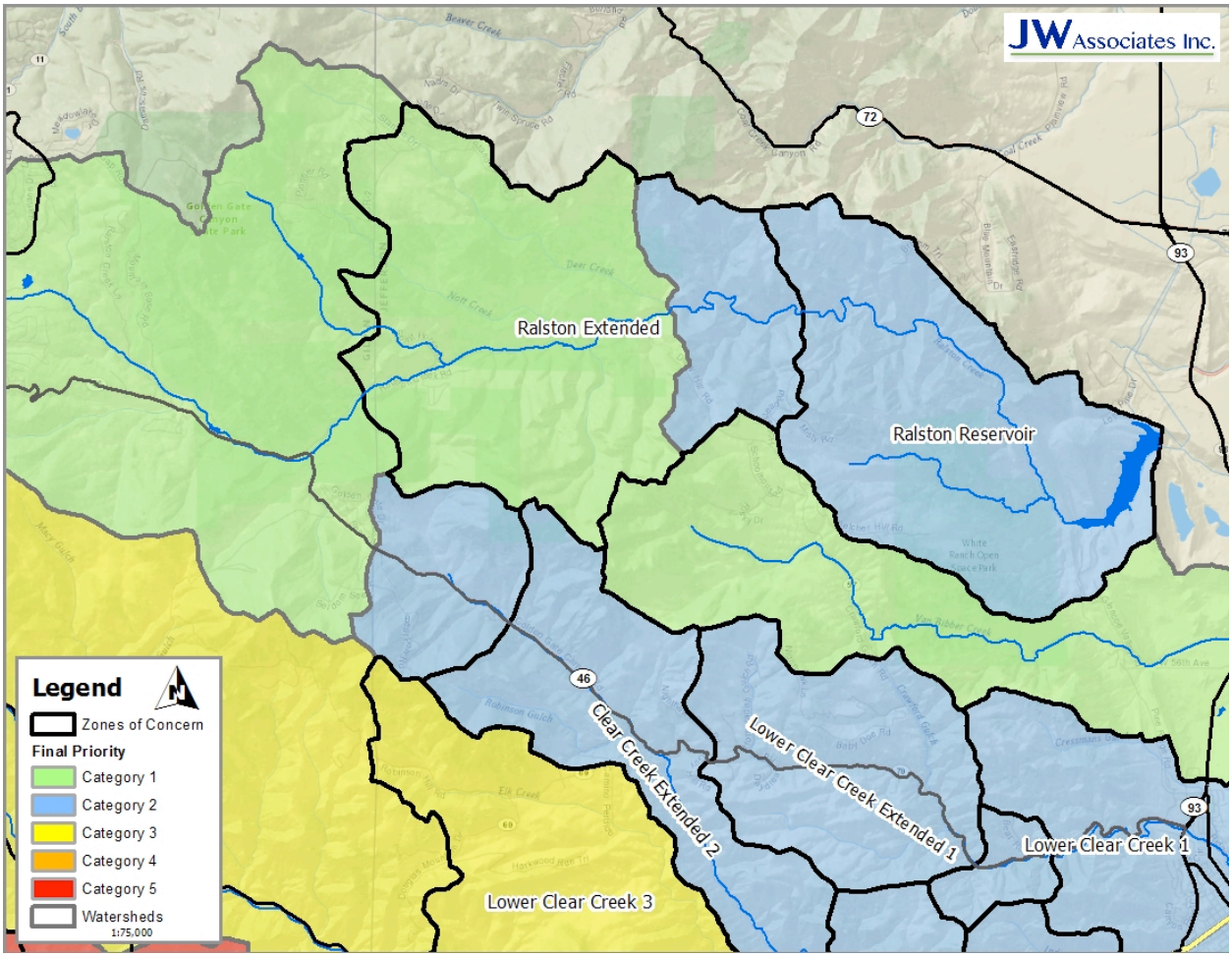


Figure 67. Ralston Reservoir ZoC Watershed Priority

Ralston Reservoir Slopes

The primary steep areas are those surrounding Ralston Creek within the Ralston Reservoir and lower portions of the Ralston Reservoir Extended ZoC (Figure 68). The Ralston Reservoir Extended ZoC has two bands of steep slopes both north and south of Ralston Creek.

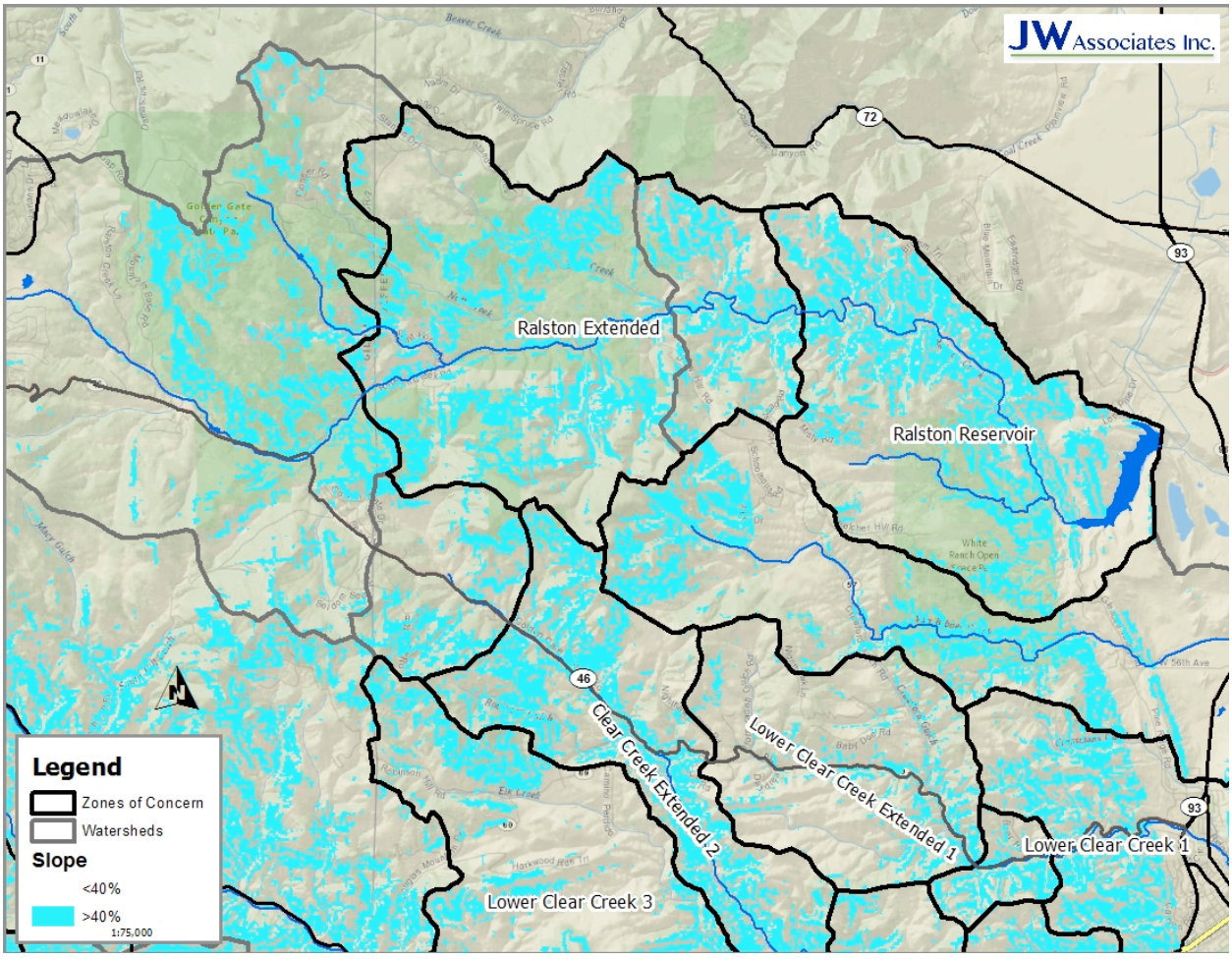


Figure 68. Ralston Reservoir ZoC Slope

Ralston Reservoir Special Management Areas

There are no special management areas in these ZoC (Figure 69).

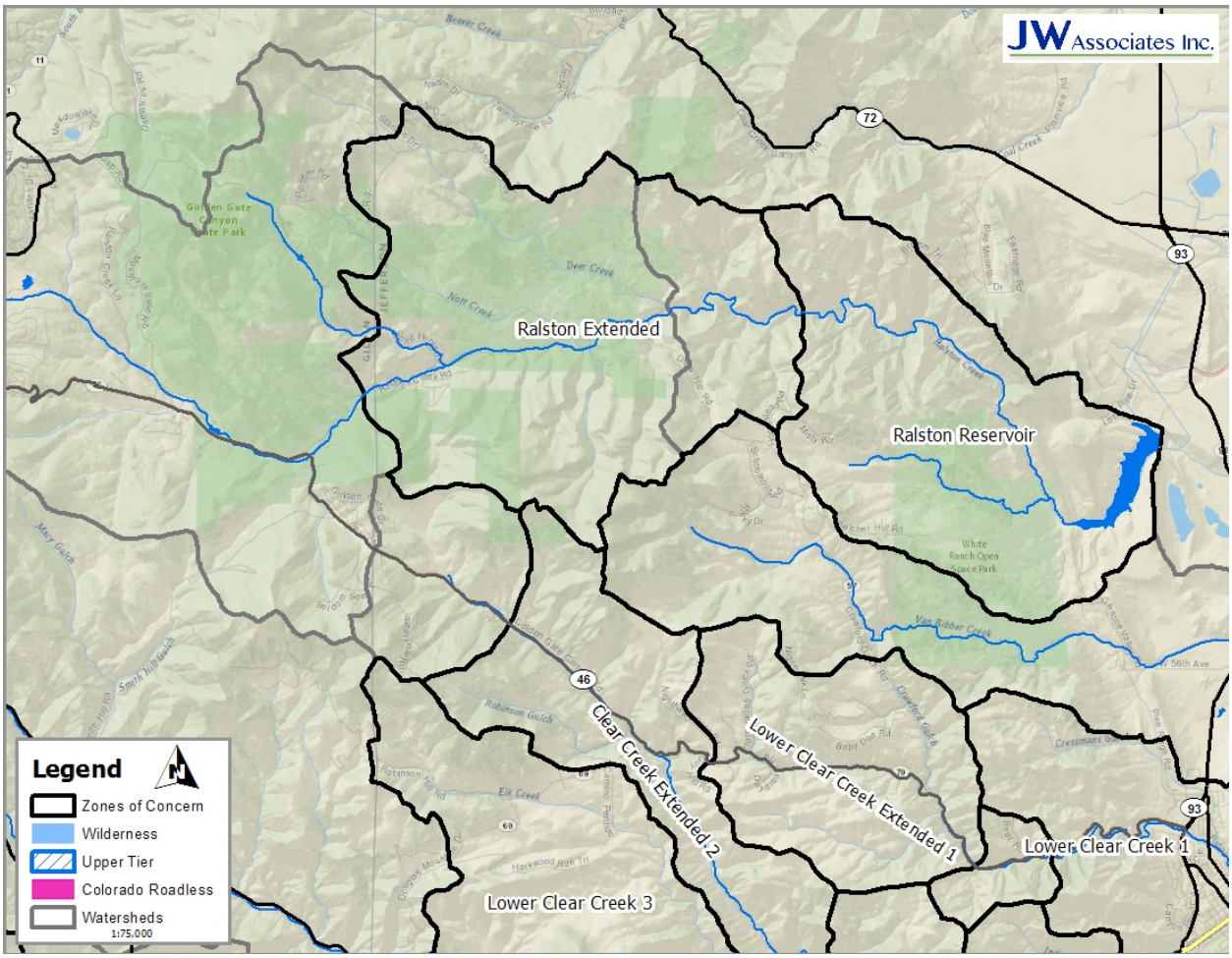


Figure 69. Ralston Reservoir ZoC Special Areas

Ralston Reservoir Vegetation

The area surrounding Ralston Reservoir is mostly ponderosa pine. The Ralston Reservoir ZoC is characterized by ponderosa pine and sagebrush on south-facing slopes and mostly Douglas-fir on north-facing slopes (Figure 70). The vegetation in the Ralston Reservoir Extended ZoC follows a similar pattern but there is more ponderosa pine and less sagebrush, in addition, there are areas of lodgepole pine mixed with aspen in the upper elevations.

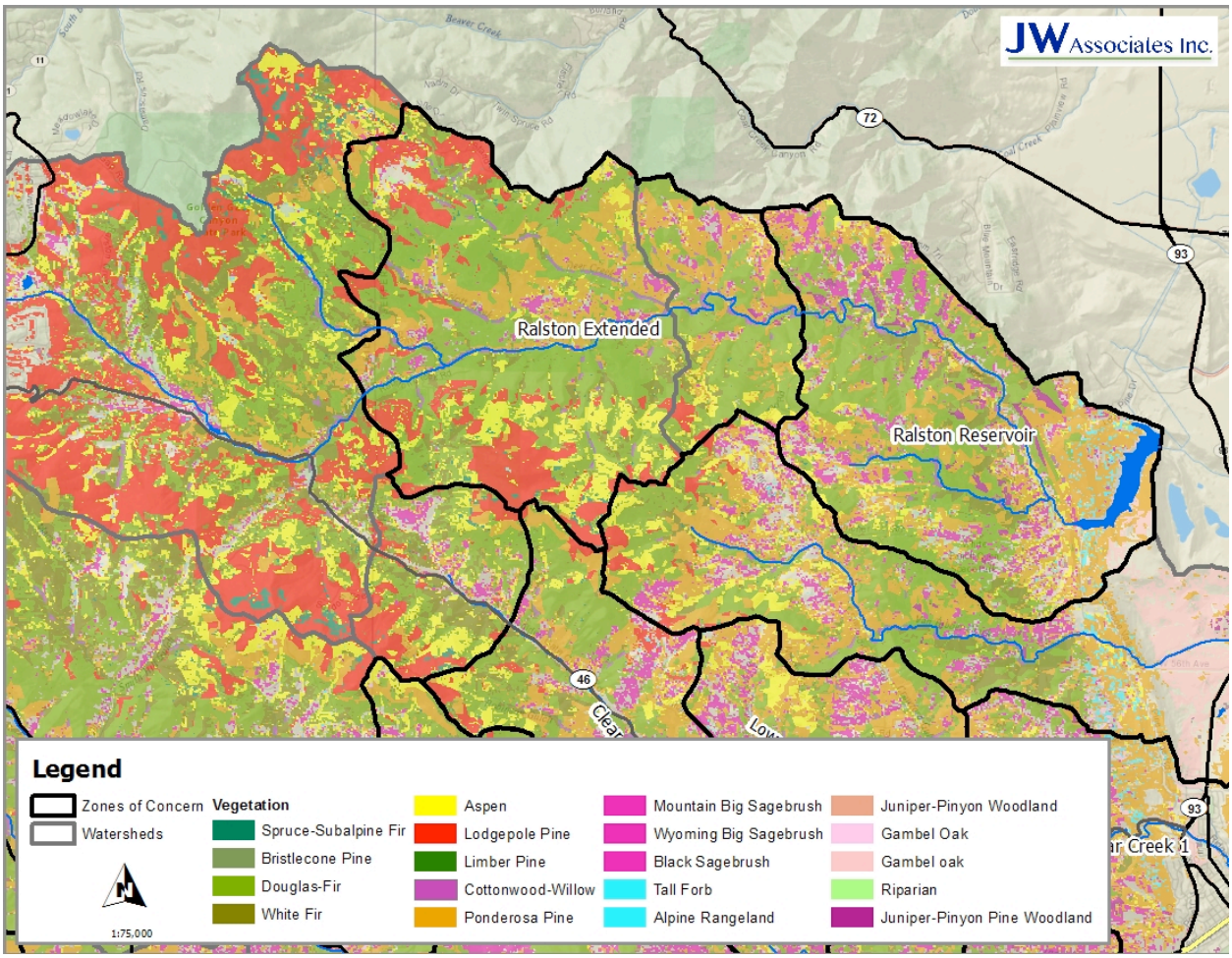


Figure 70. Ralston Reservoir ZoC Vegetation

Ralston Reservoir Access

The Ralston Reservoir ZoC and Ralston Reservoir Extended ZoC both have few existing roads, although they do provide some access to forested areas (Figure 71).

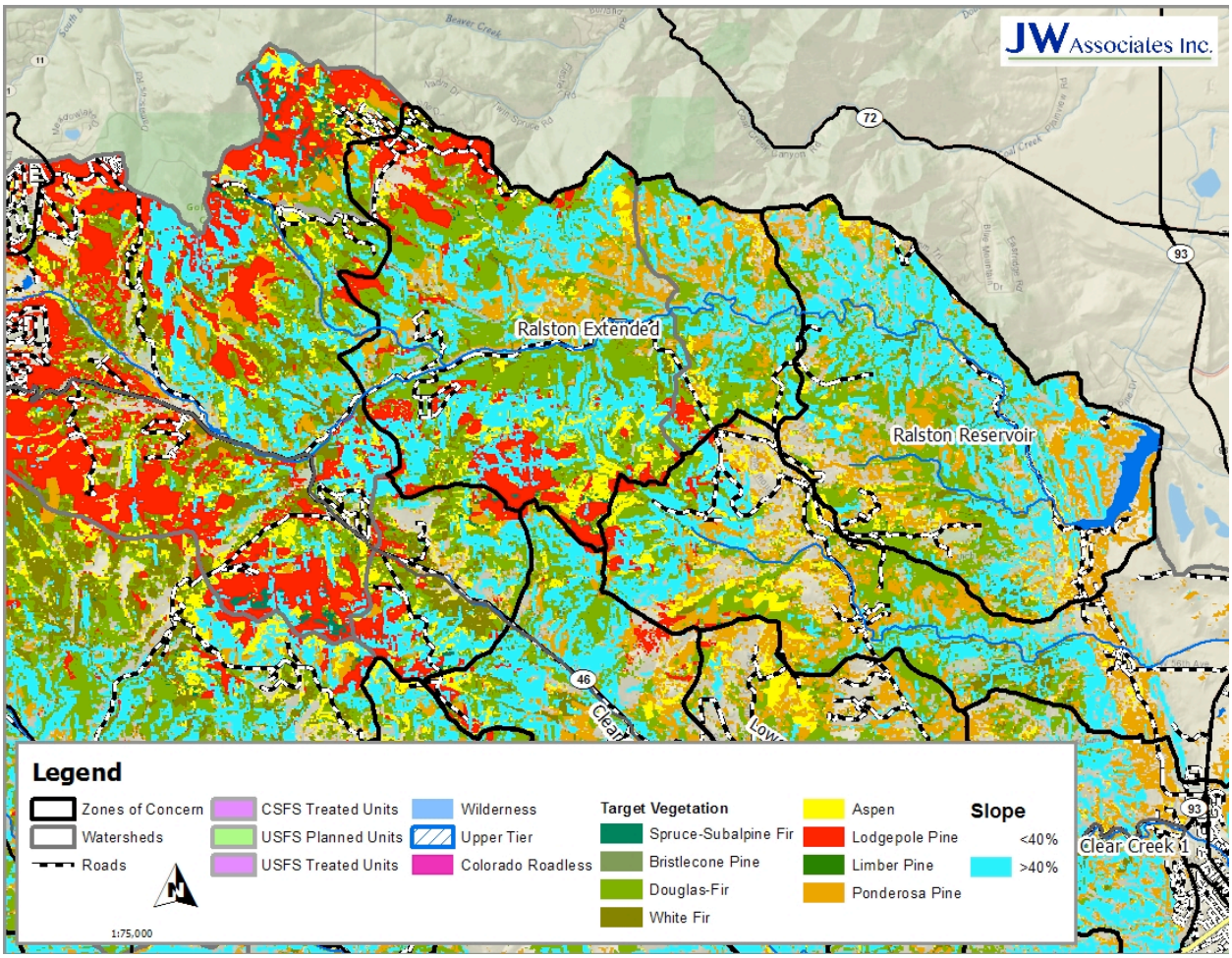
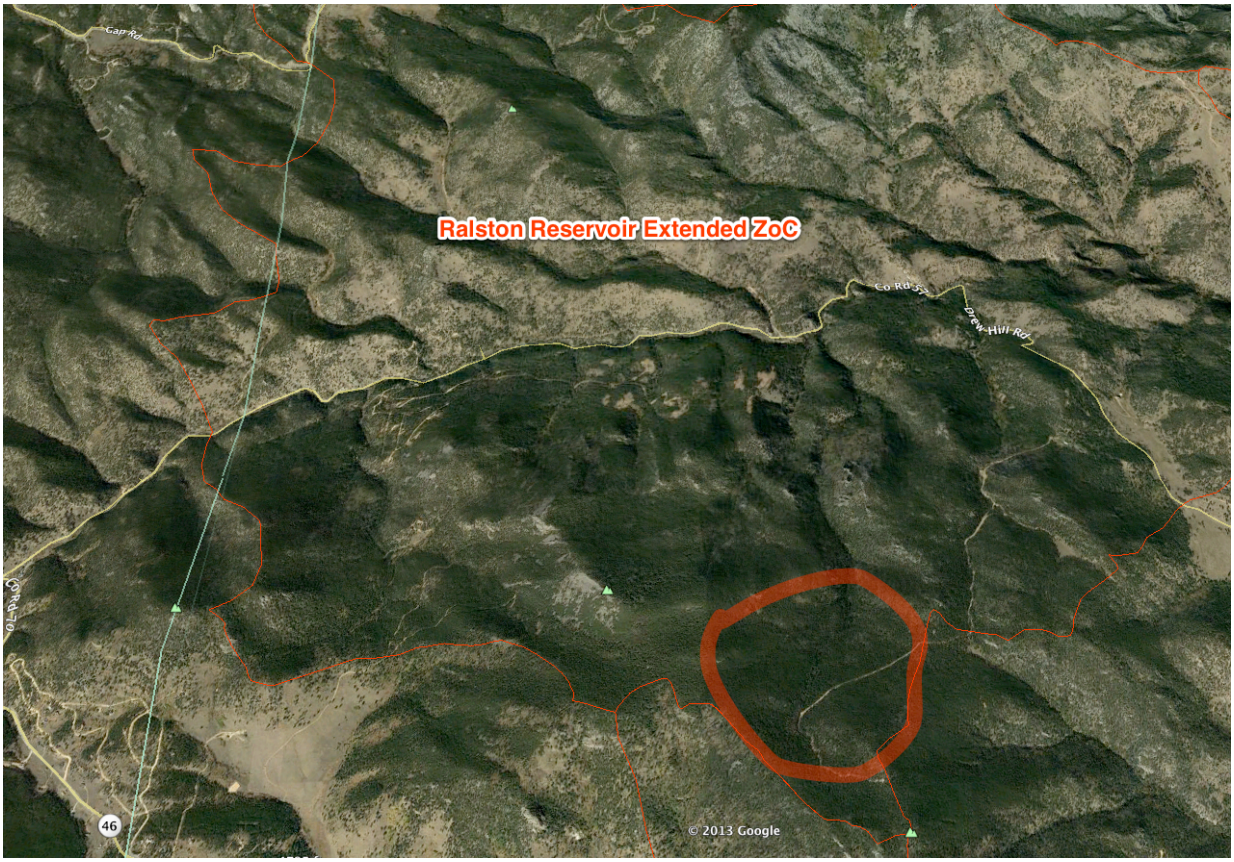


Figure 71. Ralston Reservoir ZoC Opportunities

Ralston Reservoir Opportunities

The Ralston Reservoir ZoC has limited opportunities because of lack of existing access and the open nature of this low elevation forest. There may be some opportunities to reduce wildfire hazard in specific small watersheds that would have to be determined through more detail analysis. The Ralston Reservoir Extended ZoC has some opportunities for forest treatments especially south of County Road 57. That area has relatively dense forest on north-facing slopes. The lower elevations in this area are Douglas-fir which could be thinned or removed in some places to create a ponderosa pine forest. The upper elevations contain lodgepole pine and aspen that can be accessed by one existing road. These areas could be treated to increase the age-class diversity in lodgepole pine and enhance or regenerate aspen.



Lower Clear Creek ZoC

This section discusses the Lower Clear Creek 1 and 2 and Lower Clear Creek Extended 1 ZoC because they are adjacent or overlapping (Figure 72). The Lower Clear Creek 3 ZoC and Lower Clear Creek Extended 2 ZoC are discussed in the next section. Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

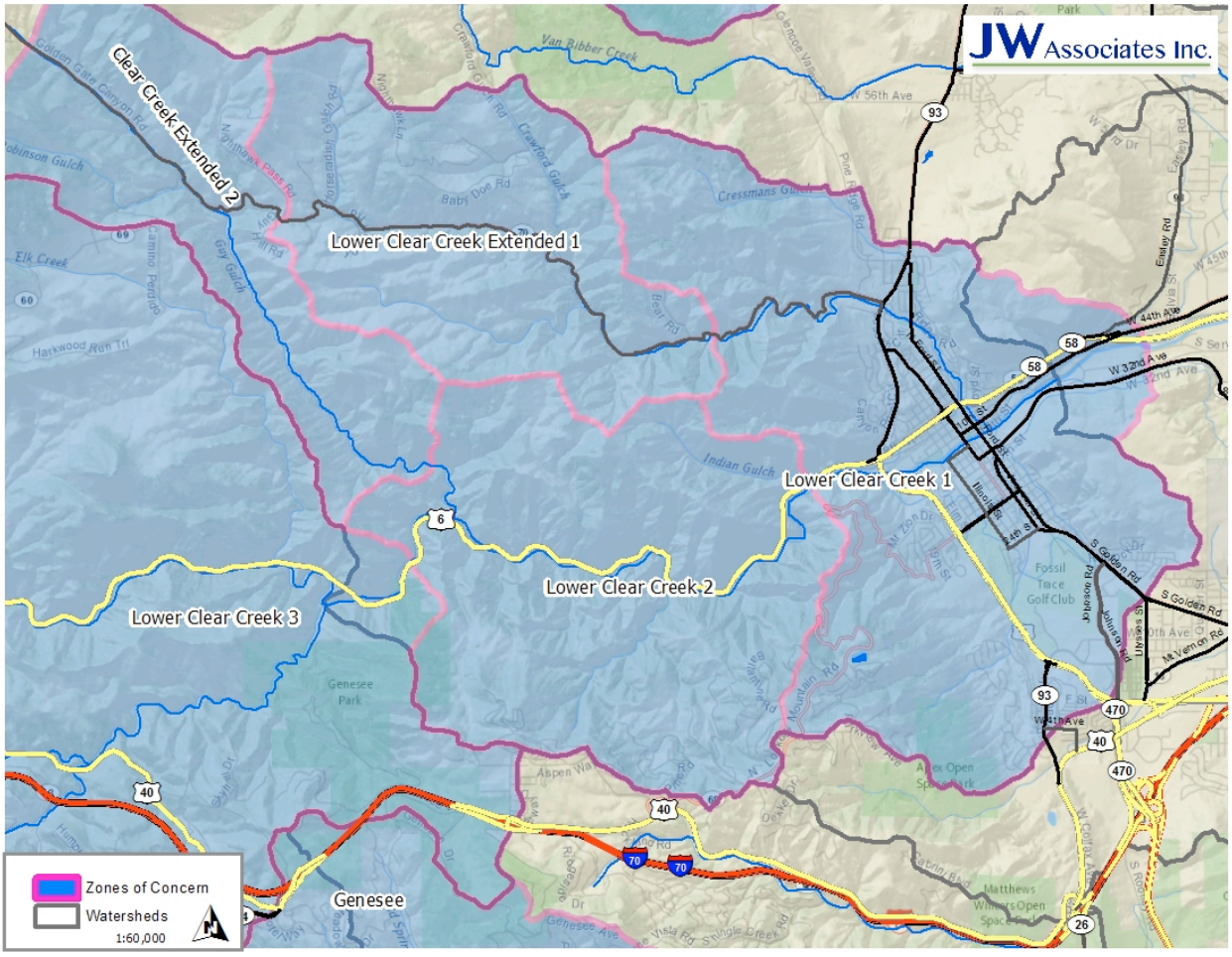


Figure 72. Lower Clear Creek ZoC Location

Lower Clear Creek Ownership

The Lower Clear Creek 1 ZoC contains large areas of private lands (Figure 73). It also has numerous parks and open space owned by Jefferson County, including Apex Park, Mount Galbraith Park, and Windy Saddle Park. The Lower Clear Creek 2 ZoC is mostly private lands with large areas of Jefferson County Open Space and portions of Mount Galbraith Park, and Windy Saddle Park, and a small area of Genesee Park. The Lower Clear Creek Extended 1 ZoC is nearly all private lands (Figure 73).

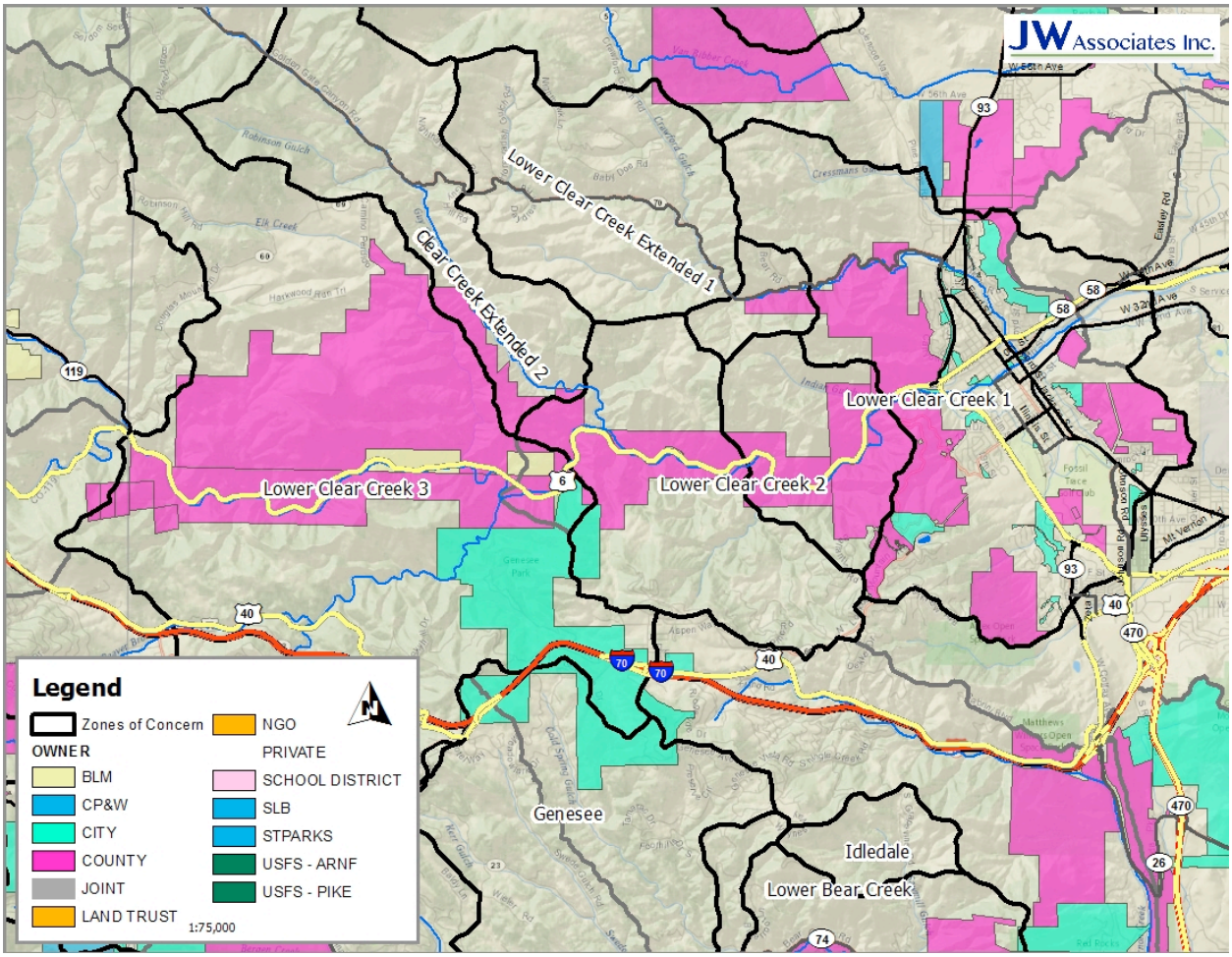


Figure 73. Lower Clear Creek ZoC Ownership

Lower Clear Creek Watershed Priority

These three ZoC are all within the Clear Creek Canyon watershed (Figure 74) that is ranked Blue (Category 2) overall.

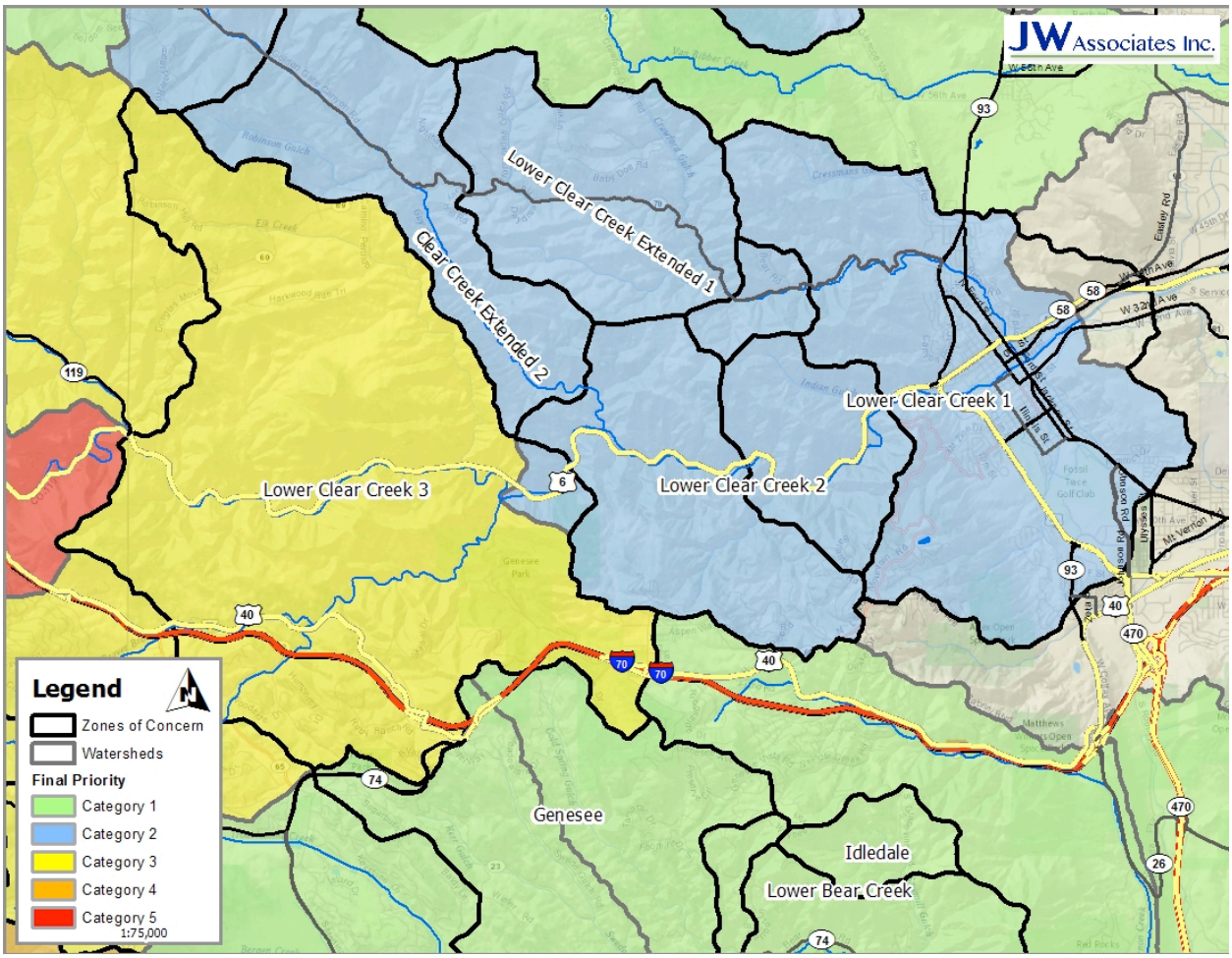


Figure 74. Lower Clear Creek ZoC Watershed Priority

Lower Clear Creek Slopes

The eastern portion of Lower Clear Creek 1 ZoC is relatively shallow but the western portion is mostly steep slopes (Figure 75). The Lower Clear Creek 2 ZoC is characterized by steep slopes within Clear Creek Canyon and some shallow slopes at higher elevations outside the canyon. The Lower Clear Creek Extended 1 ZoC has relatively shallow slopes (Figure 75).

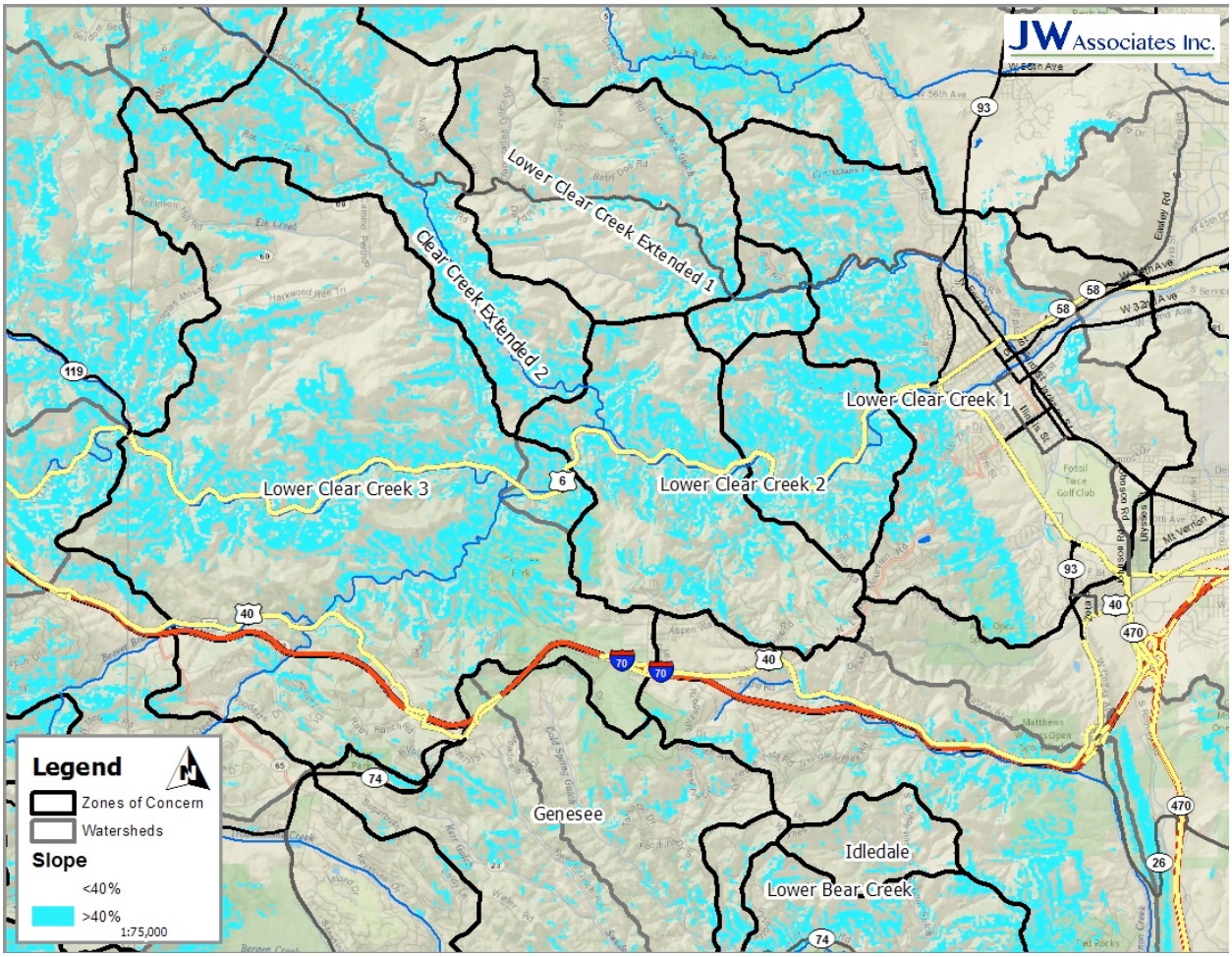


Figure 75. Lower Clear Creek ZoC Slope

Lower Clear Creek Special Management Areas

There are no special management areas in these ZoC (Figure 76).

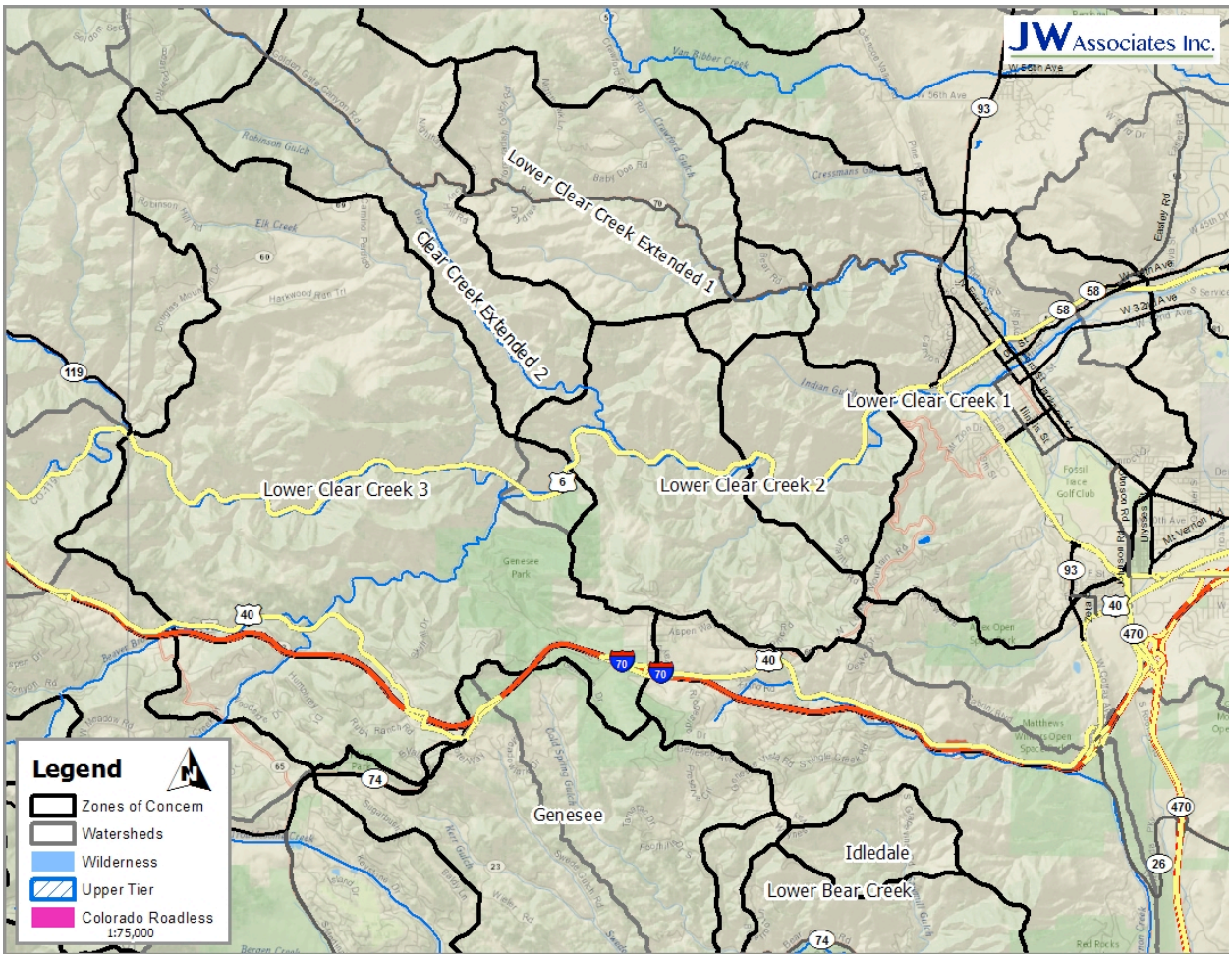


Figure 76. Lower Clear Creek ZoC Special Areas

Lower Clear Creek Vegetation

The eastern portion of the Lower Clear Creek 1 ZoC is part of the City of Golden but does contain some areas of ponderosa pine (Figure 77). The western portion of Lower Clear Creek 1 ZoC and all of Lower Clear Creek 2 ZoC are characterized by south-facing slopes that have a mixture of sagebrush, ponderosa pine and Douglas-fir, with north-facing slopes of Douglas-fir and ponderosa pine. The Lower Clear Creek Extended 1 ZoC has some large areas of sagebrush with other areas covered by Douglas-fir and ponderosa pine. There is also an area of aspen in the Lower Clear Creek Extended 1 ZoC.

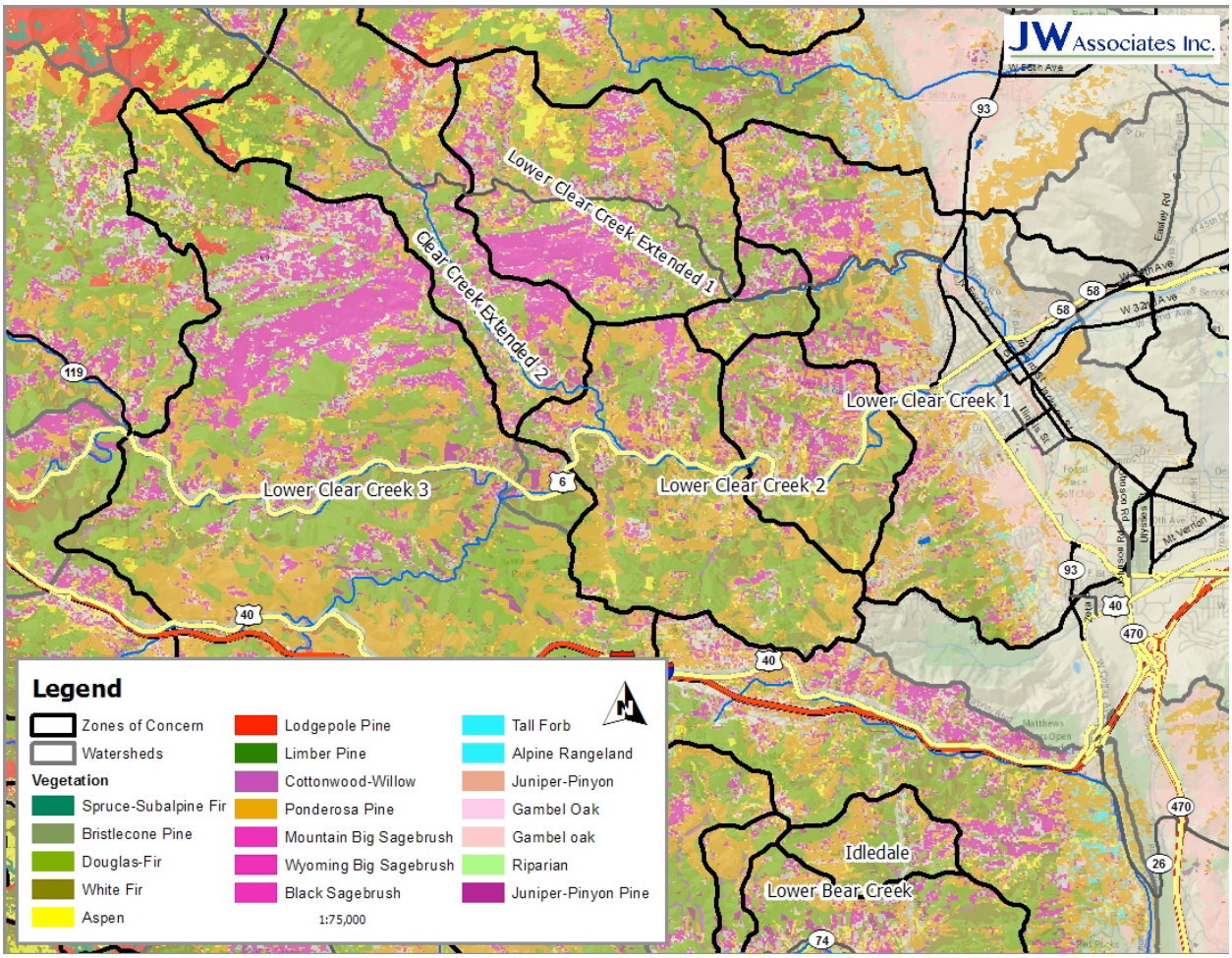


Figure 77. Lower Clear Creek ZoC Vegetation

Lower Clear Creek Access

The Lower Clear Creek 1 and 2 ZoC have substantial existing access in the southern portions, but for the remainder of these ZoC, the access is mostly limited to US Highway 6 in Clear Creek Canyon (Figure 78). The Lower Clear Creek Extended 1 ZoC has some existing access in the forested areas in the the northern portion of the ZoC.

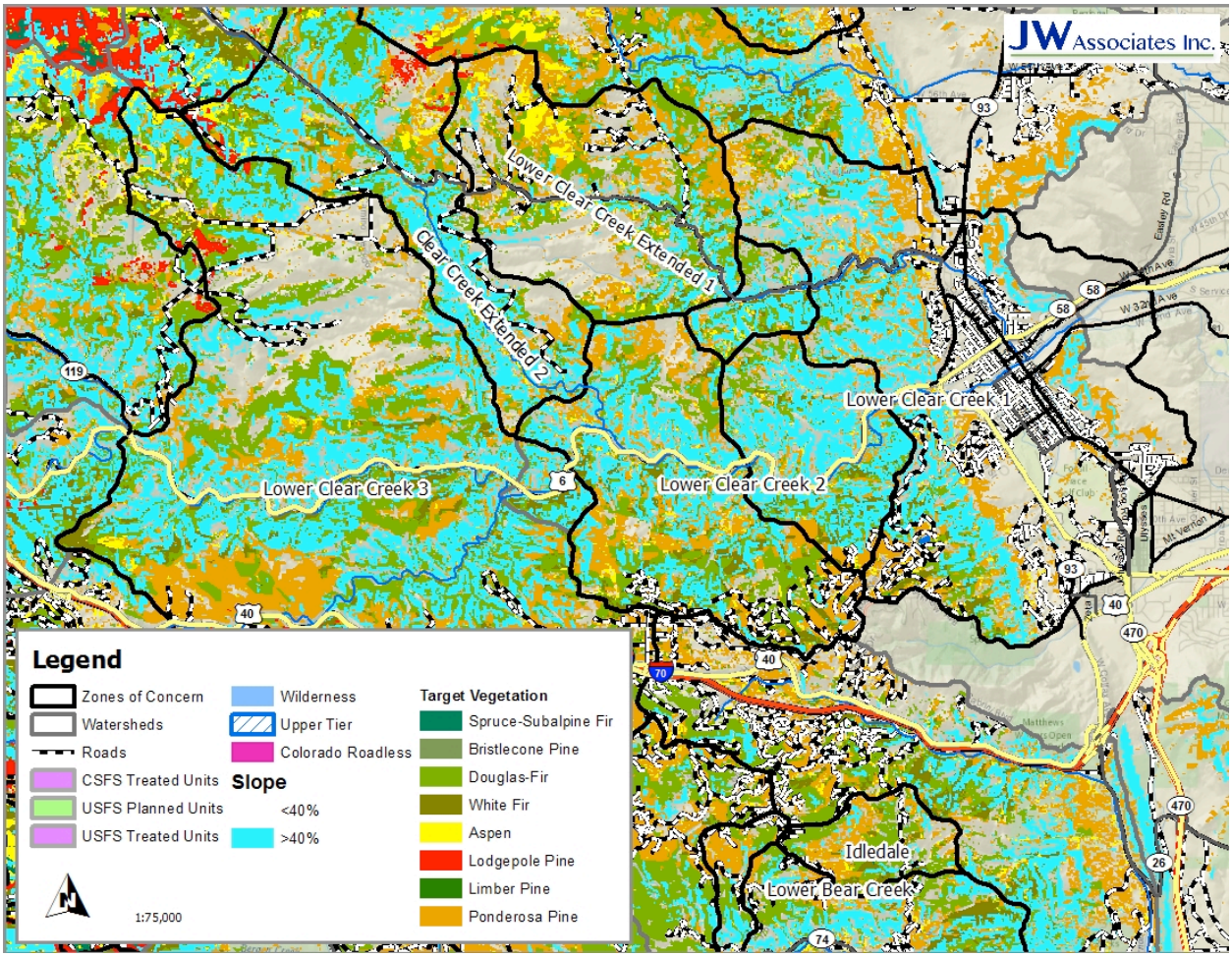


Figure 78. Lower Clear Creek ZoC Opportunities

Lower Clear Creek Opportunities

The Lower Clear Creek 1 ZoC has limited opportunities because of lack of existing access and the open nature of this low elevation forest. There may be some opportunities to reduce wildfire hazard in specific small watersheds that would have to be determined through more detail analysis.

There are some opportunities in the Lower Clear Creek 2 ZoC. One example is the area south of Clear Creek Canyon that contains a relatively dense area of Douglas-fir and ponderosa pine. Treatments in this area should be designed to thin Douglas-fir or remove it in favor of ponderosa pine. This area is the headwaters of one of the steep tributaries that flows into Clear Creek.

There are some opportunities in Lower Clear Creek Extended 1 ZoC. There are many roads in this ZoC because of the extensive area of private lands. The forest in this ZoC is relatively open but there may be some opportunities to reduce wildfire hazard in specific small watersheds that would have to be determined through more detail analysis.

Lower Clear Creek Extended ZoC

This section discusses the Lower Clear Creek 3 and Lower Clear Creek Extended 2 ZoC because they are adjacent or overlapping (Figure 79). The Lower Clear Creek 1 and 2 ZoC and Lower Clear Creek Extended 1 ZoC are discussed in the previous section. Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

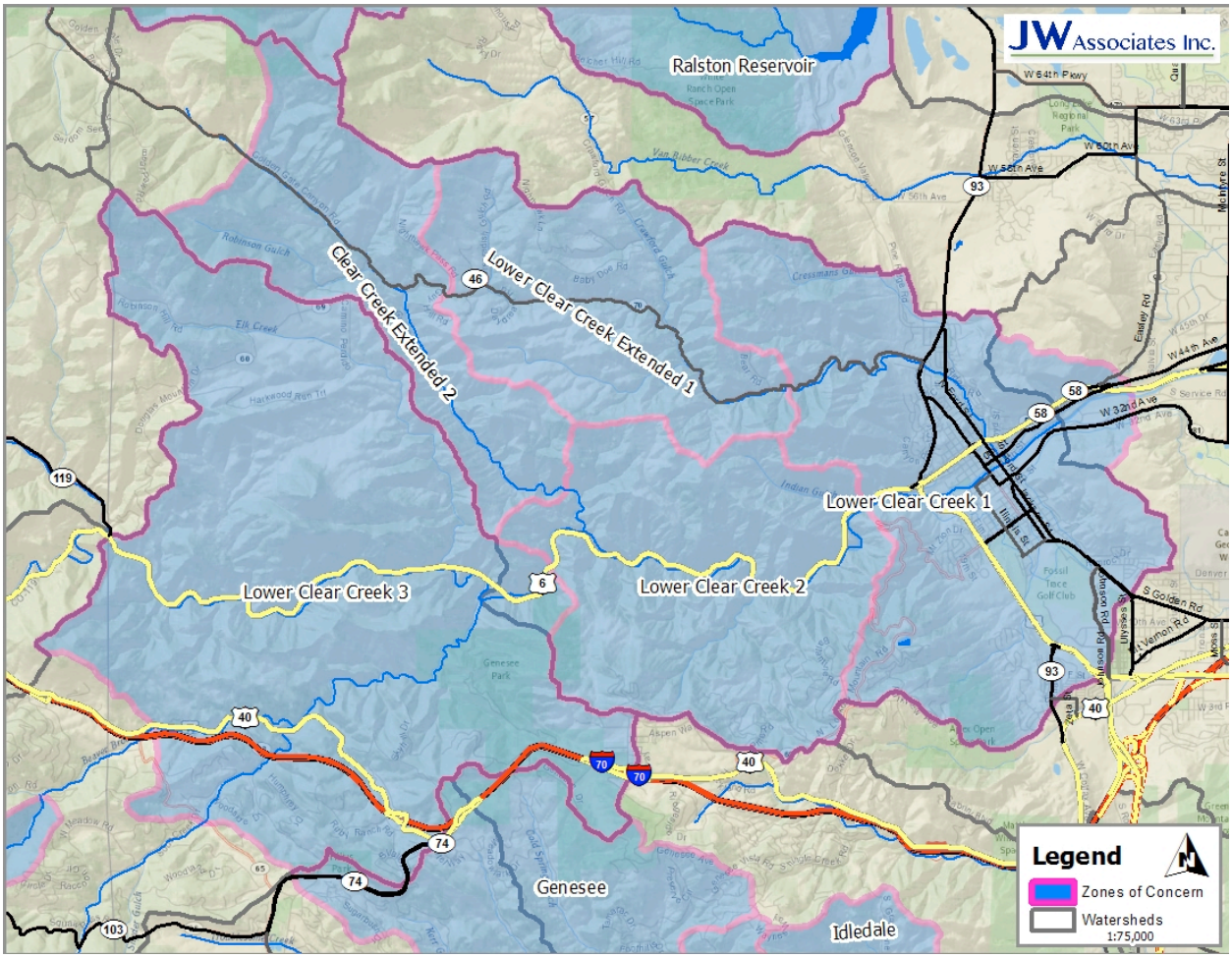


Figure 79. Lower Clear Creek Extended ZoC Location

Lower Clear Creek Extended Ownership

The Lower Clear Creek 3 ZoC contains a large area of Jefferson County Open Space and a large portion of Genesee Park with the remainder in private lands (Figure 80). The Lower Clear Creek Extended 2 ZoC is mostly private lands with some Jefferson County Open Space in the southern portion.

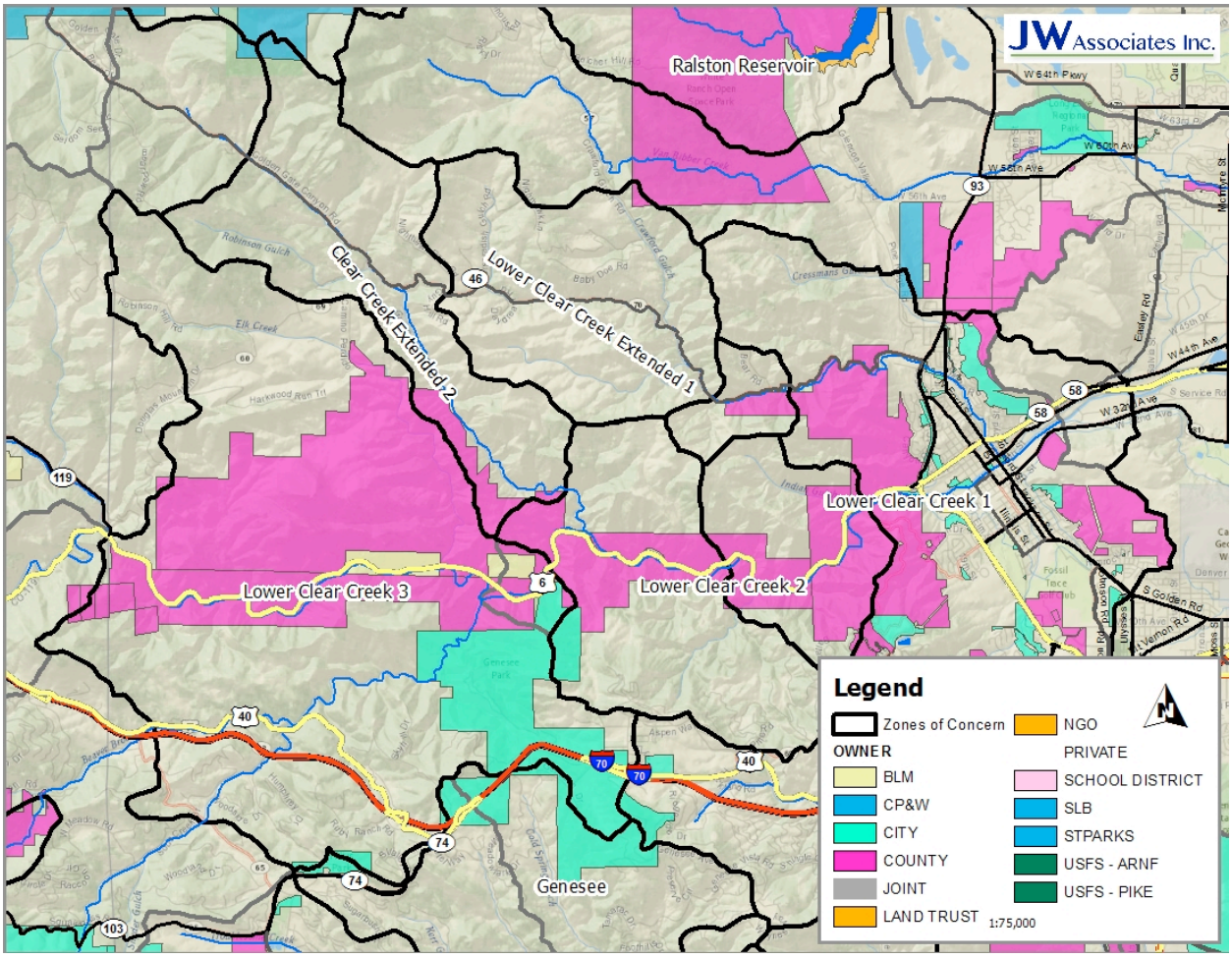


Figure 80. Lower Clear Creek Extended ZoC Ownership

Lower Clear Creek Extended Watershed Priority

The Lower Clear Creek 3 ZoC is within the Beaver Brook-Clear Creek watershed (Figure 81) that is ranked Yellow (Category 3) overall, and Orange (Category 4) for Flooding/Debris Flow Hazard. The Lower Clear Creek Extended 2 ZoC is within the Clear Creek Canyon watershed that is ranked Blue (Category 2) overall.

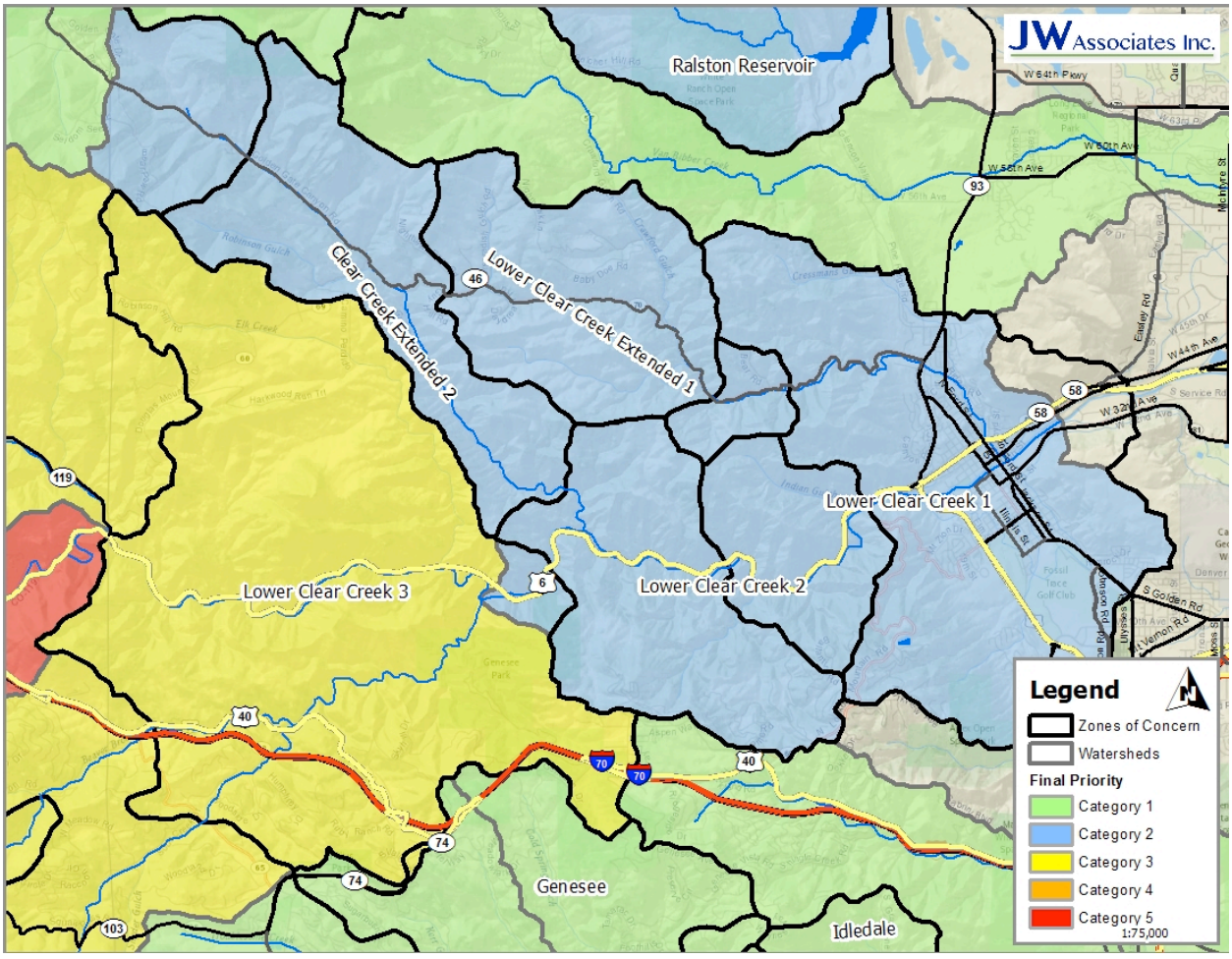


Figure 81. Lower Clear Creek Extended ZoC Watershed Priority

Lower Clear Creek Extended Slopes

The Lower Clear Creek 3 ZoC is characterized by mostly shallow slopes throughout (Figure 82) except for Clear Creek Canyon and the areas surrounding Beaver Brook. The Lower Clear Creek Extended 2 ZoC is characterized by mostly steep slopes throughout (Figure 82) especially surrounding Guy Gulch.

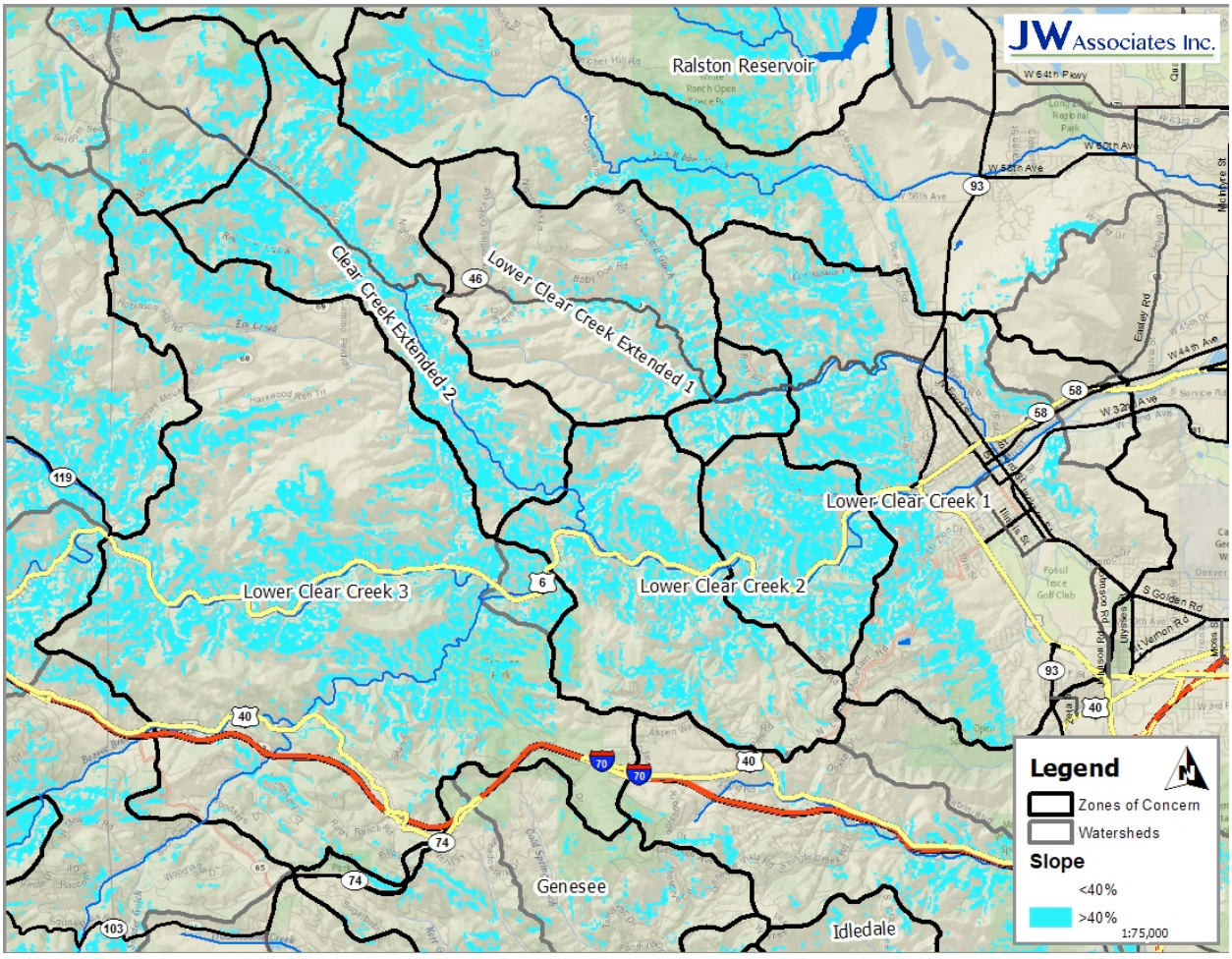


Figure 82. Lower Clear Creek Extended ZoC Slope

Lower Clear Creek Extended Special Management Areas

There are no special management areas in these ZoC (Figure 83).

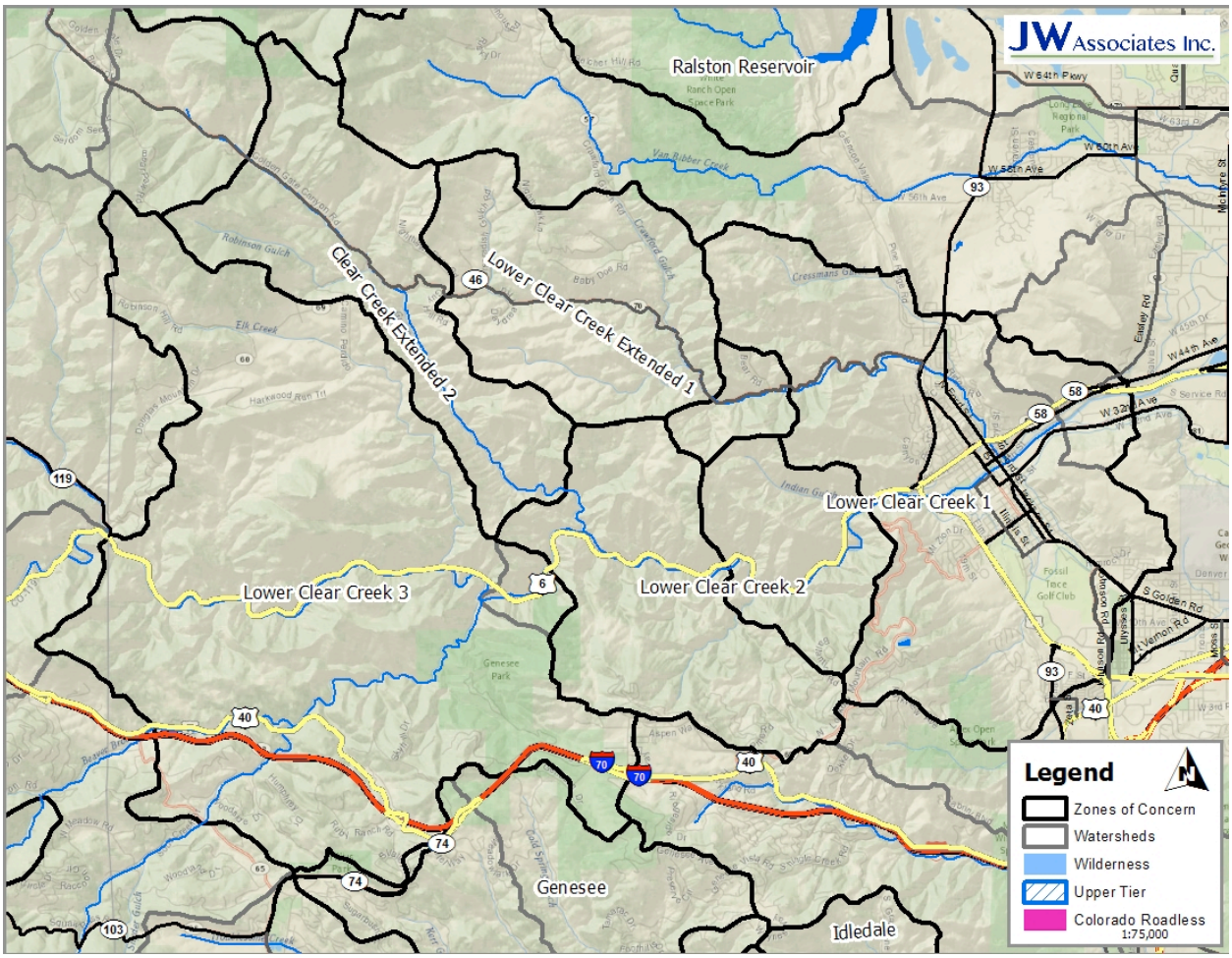


Figure 83. Lower Clear Creek Extended ZoC Special Areas

Lower Clear Creek Extended Vegetation

The Lower Clear Creek 3 ZoC contains a large are of sagebrush in the northern portion of the ZoC (Figure 84). The rest of the Lower Clear Creek 3 ZoC is characterized by north-facing slopes that are generally dominated by Douglas-fir and south-facing slopes that are dominated by ponderosa pine mixed with Douglas-fir. The Lower Clear Creek Extended 2 ZoC is mostly Douglas-fir with areas of ponderosa pine, but does include some areas of sagebrush.

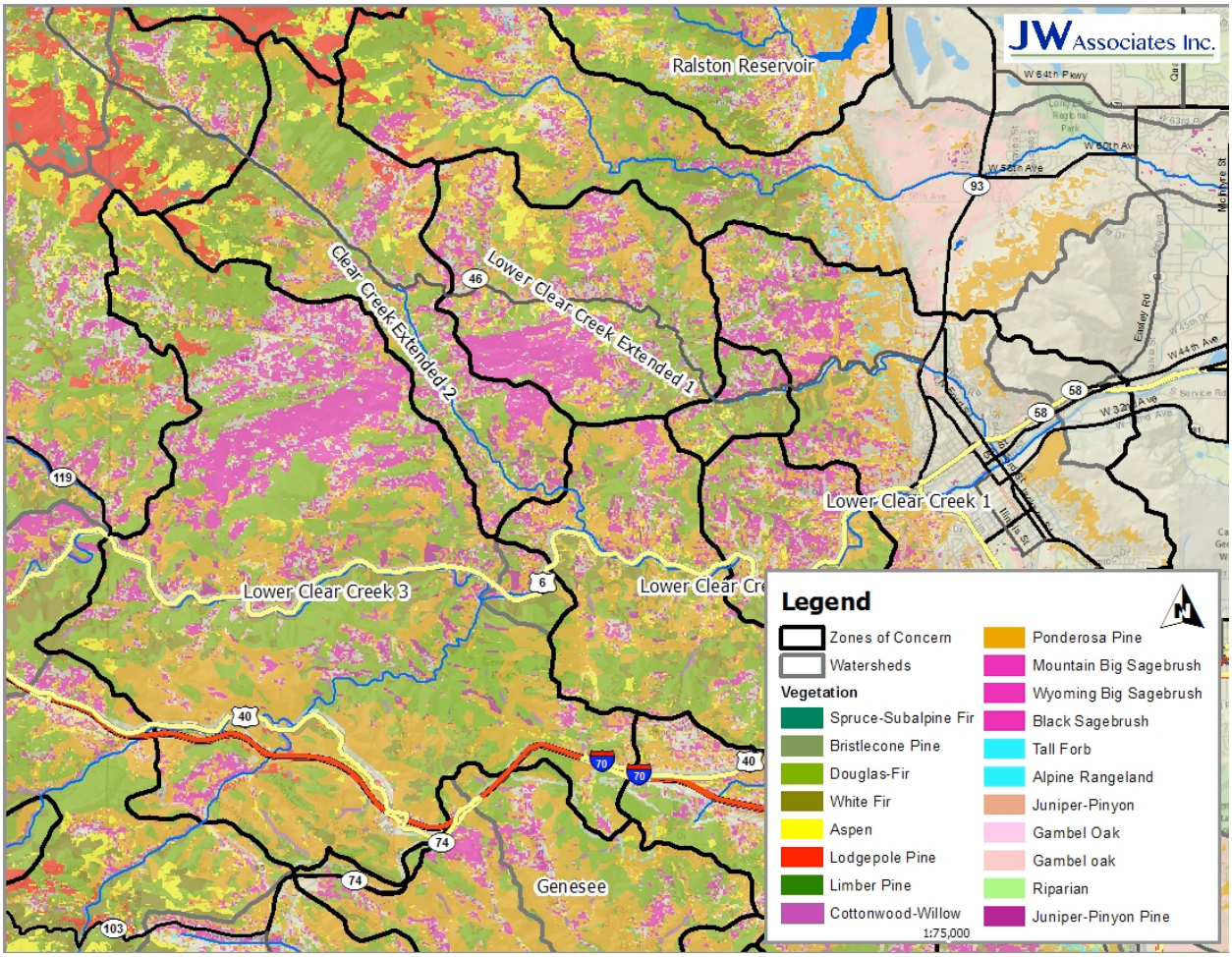


Figure 84. Lower Clear Creek Extended ZoC Vegetation

Lower Clear Creek Extended Access

There are extensive existing roads in the southern portion of the Lower Clear Creek 3 ZoC near Interstate 70 (Figure 85). There are also some existing roads in the far northern portion. However, most of the Lower Clear Creek 3 ZoC lacks access except for US Highway 6 in Clear Creek Canyon. The Lower Clear Creek Extended 2 ZoC has some access but it is limited to mainly one road that runs along Guy Gulch.

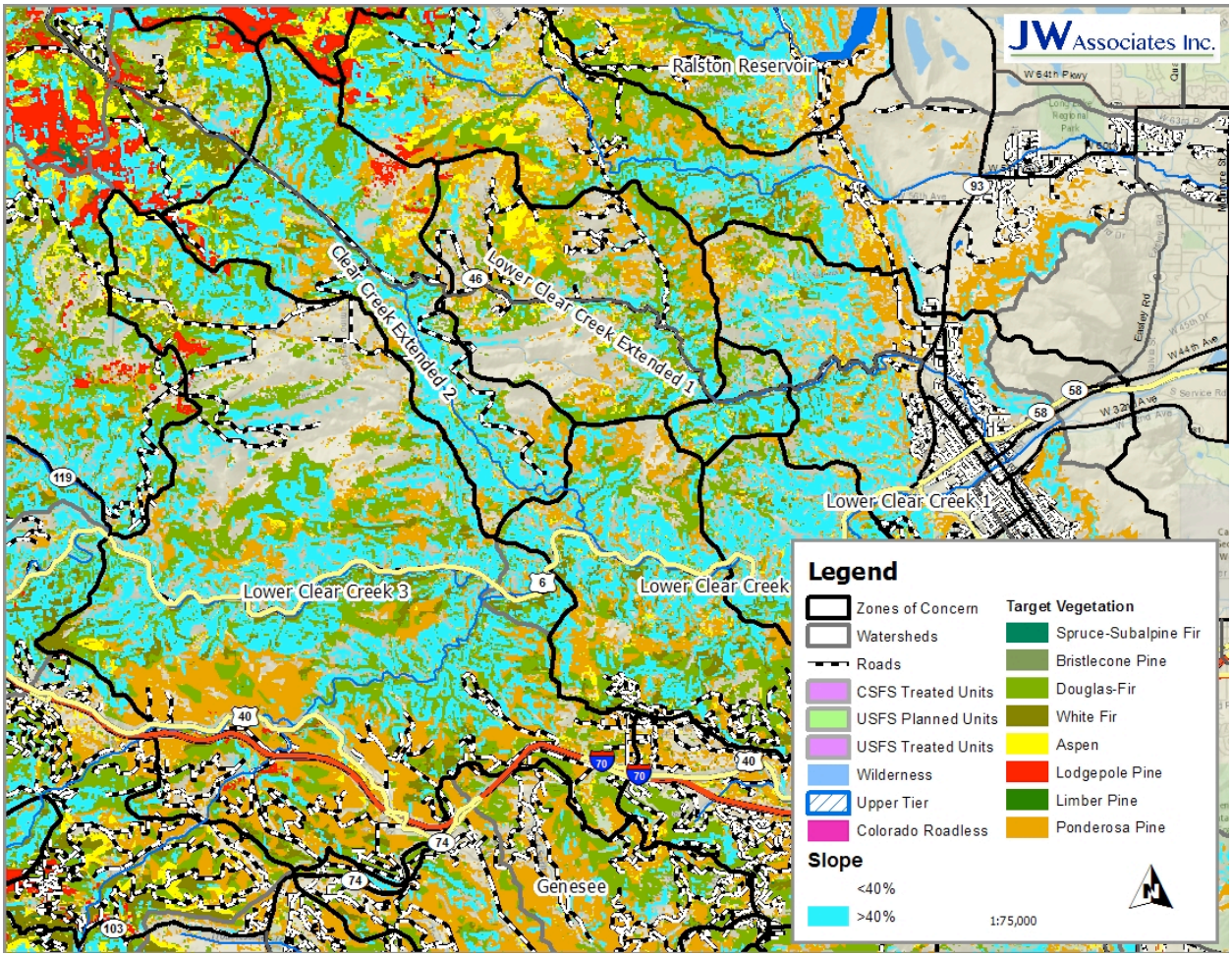
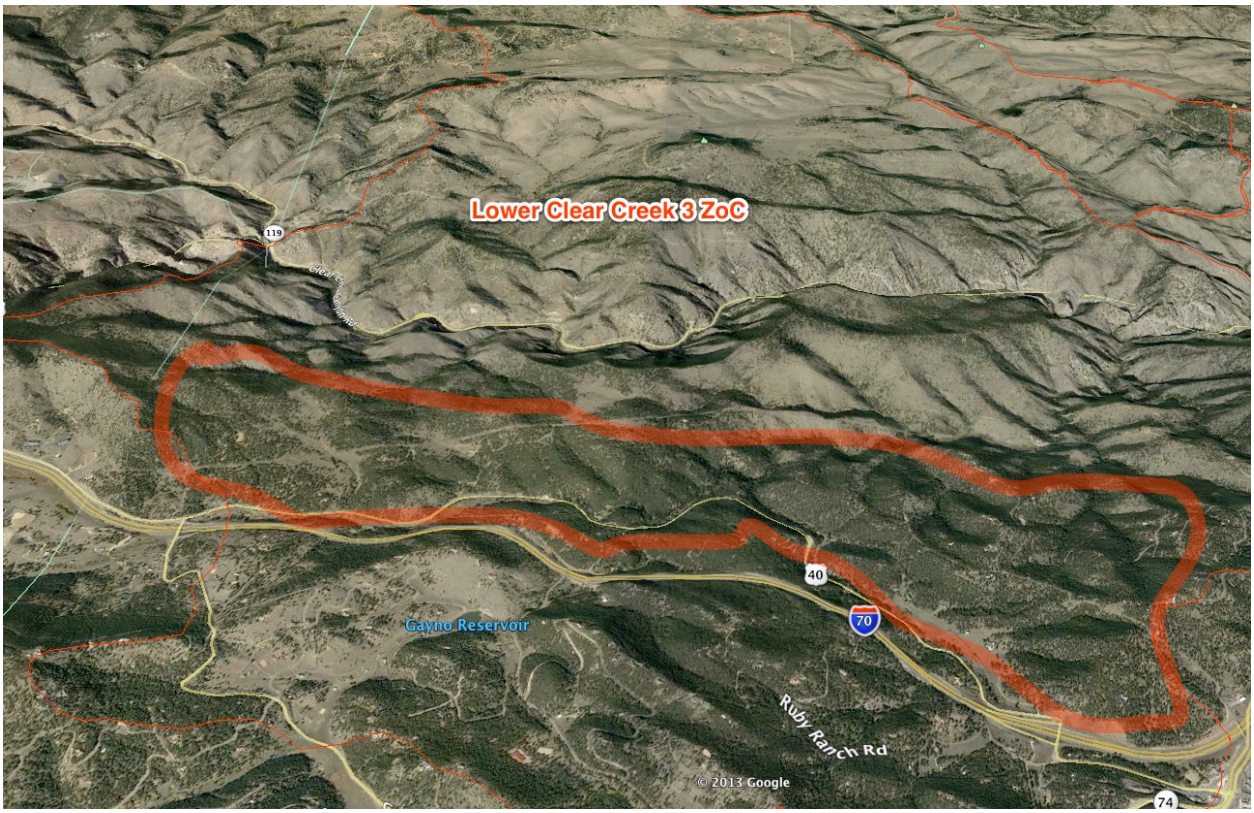


Figure 85. Lower Clear Creek Extended ZoC Opportunities

Lower Clear Creek Extended Opportunities

The Lower Clear Creek 3 ZoC has some opportunities. The north-facing slopes south of Clear Creek Canyon are all private lands with good access. There are also some areas of dense forests that occupy the upper slopes of tributaries to Clear Creek. Because this area is so large, some additional targeting would be needed identify specific areas that could be treated.

The Lower Clear Creek Extended 2 ZoC has limited opportunities due to steep slopes and lack of access. There may be some watershed protection opportunities in this ZoC but they would have to be identified with more detailed analysis.



Evergreen Lake ZoC

This section discusses the Evergreen Lake, Evergreen Lake Extended and Singing Rock ZoC because they are adjacent or overlapping (Figure 86). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

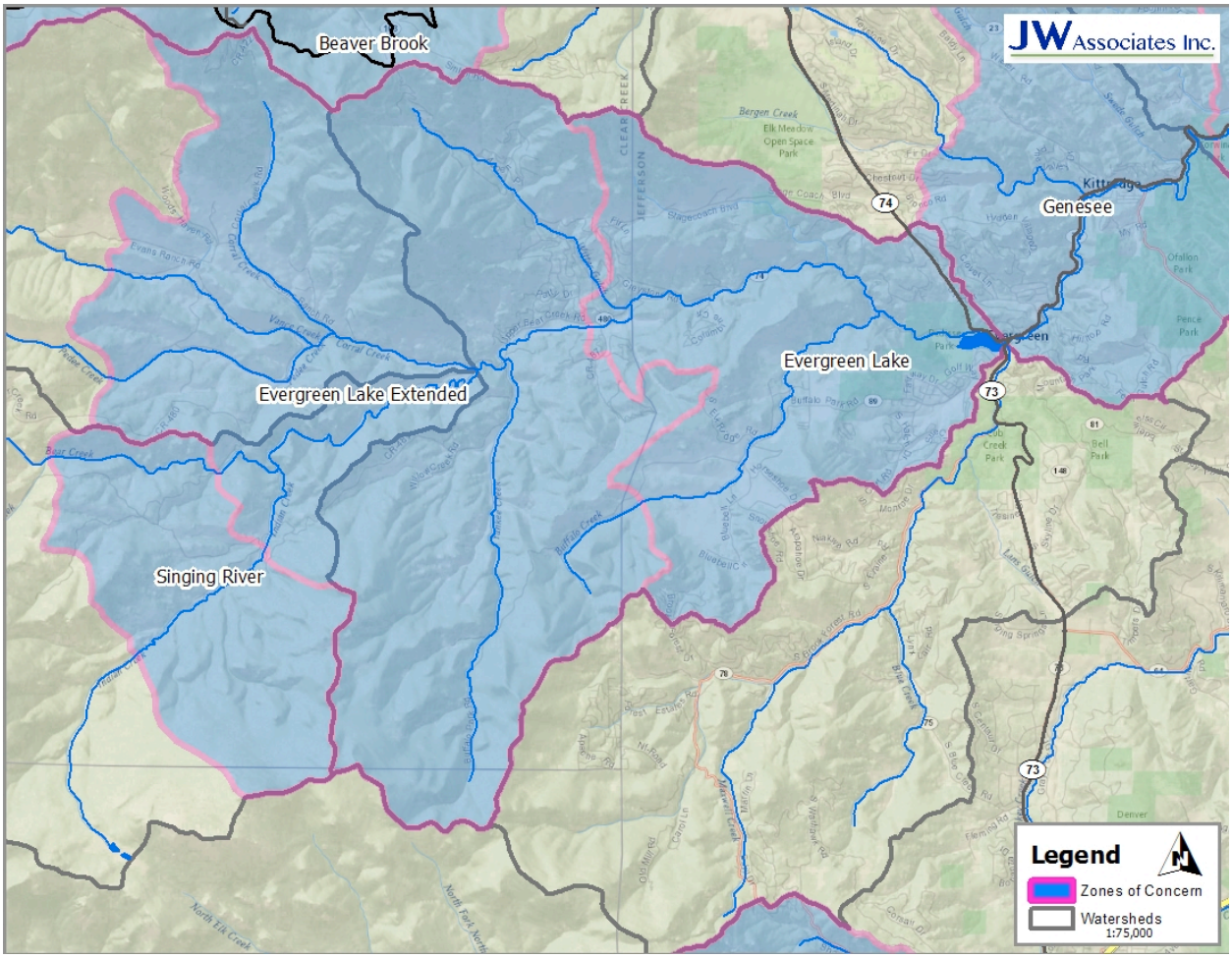


Figure 86. Evergreen Lake ZoC Location

Evergreen Lake Ownership

The Evergreen Lake ZoC contains a large area of private lands (Figure 87) with significant areas of parks and other special areas, including Dedisse Park, Alderfer/Three Sisters Park, Elk Meadow Park, and Bergen Peak Special Wildlife Area. The Evergreen Lake Extended ZoC is also mostly private lands with some NFS lands, Denver Mountain Parks, and both the Mount Evans and Bergen Peak Special Wildlife Areas. The Singing River ZoC has private lands surrounding Indian Creek, with large areas of NFS lands and the Mount Evans and Special Wildlife Area (Figure 87).

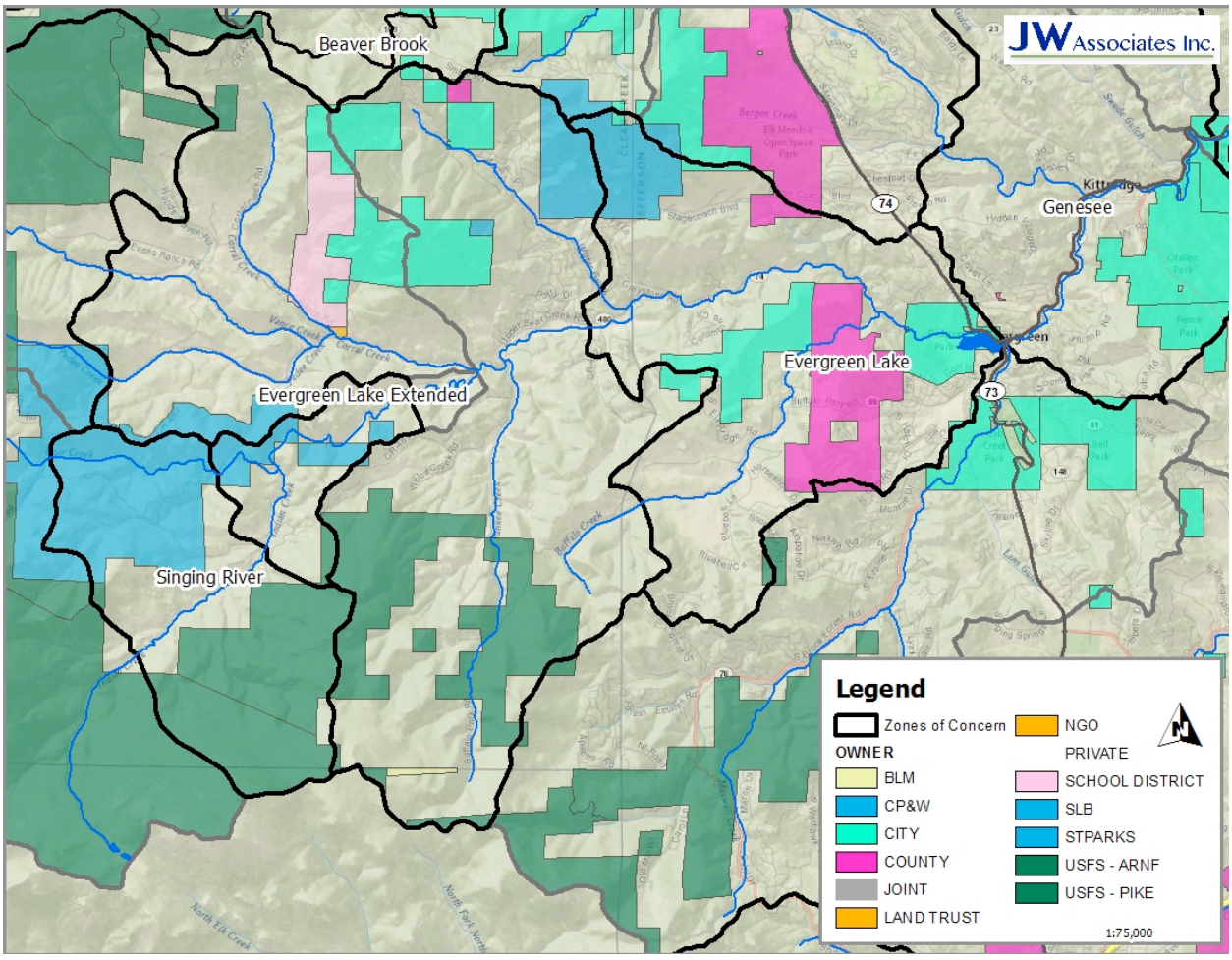


Figure 87. Evergreen Lake ZoC Ownership

Evergreen Lake Watershed Priority

The Evergreen Lake and eastern part of the Evergreen Lake Extended ZoC is within the Evergreen Lake-Bear Creek watershed (Figure 88) that is ranked Orange (Category 4) overall, and for Composite Hazard. The Evergreen Lake-Bear Creek watershed is also ranked Red (Category 5 - highest) for Wildfire Hazard. The Evergreen Lake Extended ZoC is also within the Vance Creek watershed that is ranked Yellow (Category 3) overall, and Red (Category 5 - highest for Soil Erodibility. The Vance Creek watershed is also ranked Orange (Category 4) for Wildfire Hazard and Composite Hazard. The Singing River ZoC and portions of the Evergreen Lake Extended ZoC are within the Headwaters Bear Creek watershed (Figure 88) that is ranked Blue (Category 2) overall.

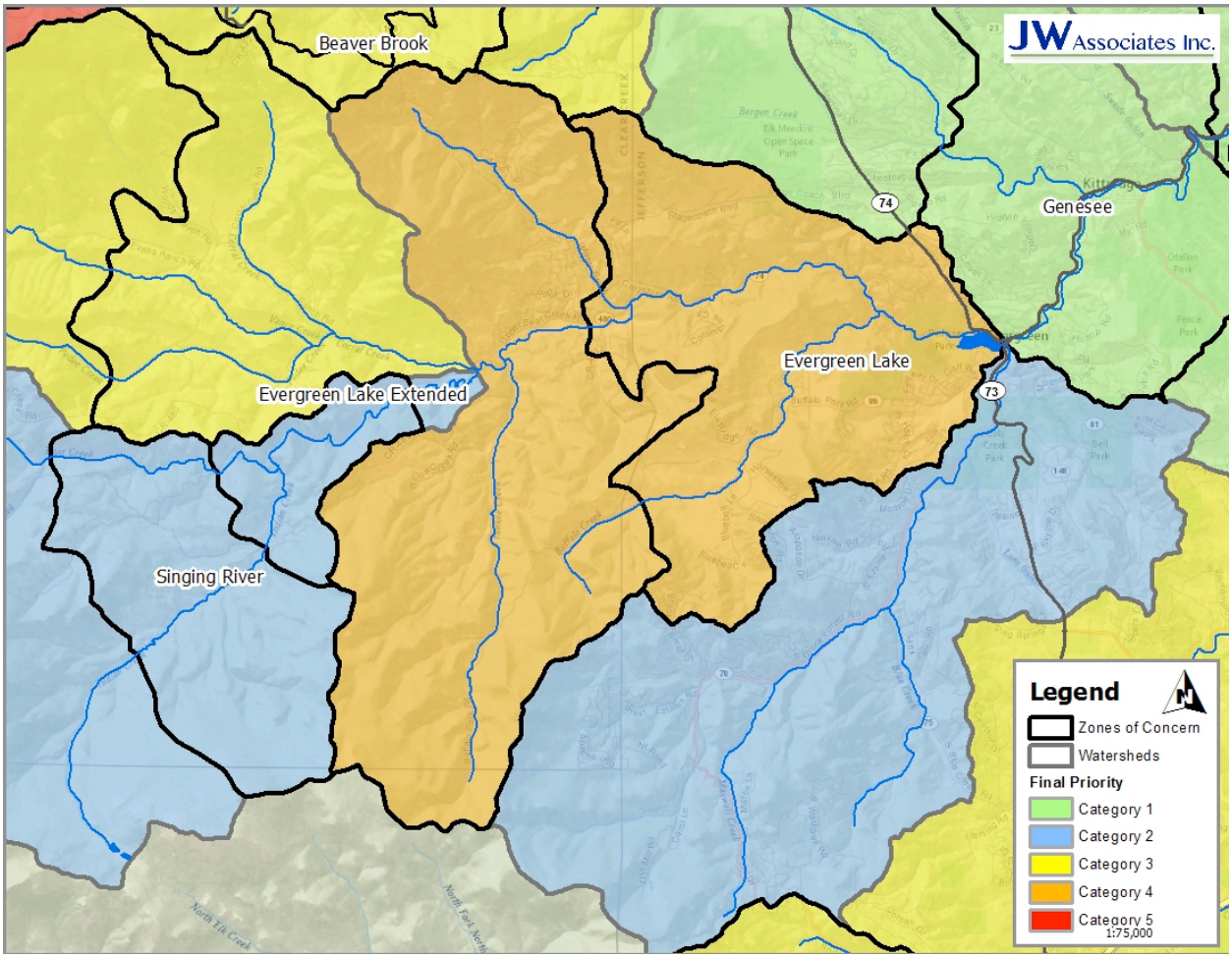


Figure 88. Evergreen Lake ZoC Watershed Priority

Evergreen Lake Slopes

The majority of the Evergreen Lake ZoC is characterized by mostly shallow slopes (Figure 89) except for some areas in the northern portion. The majority of the Evergreen Lake Extended ZoC is characterized by mostly shallow slopes with the exceptions of areas in upper Corral Creek, Witter Gulch and Bear Creek above Corral Creek. The Singing River ZoC is also characterized by mostly shallow slopes throughout (Figure 89) except for the area surrounding the lower portions of Bear Creek in this ZoC.

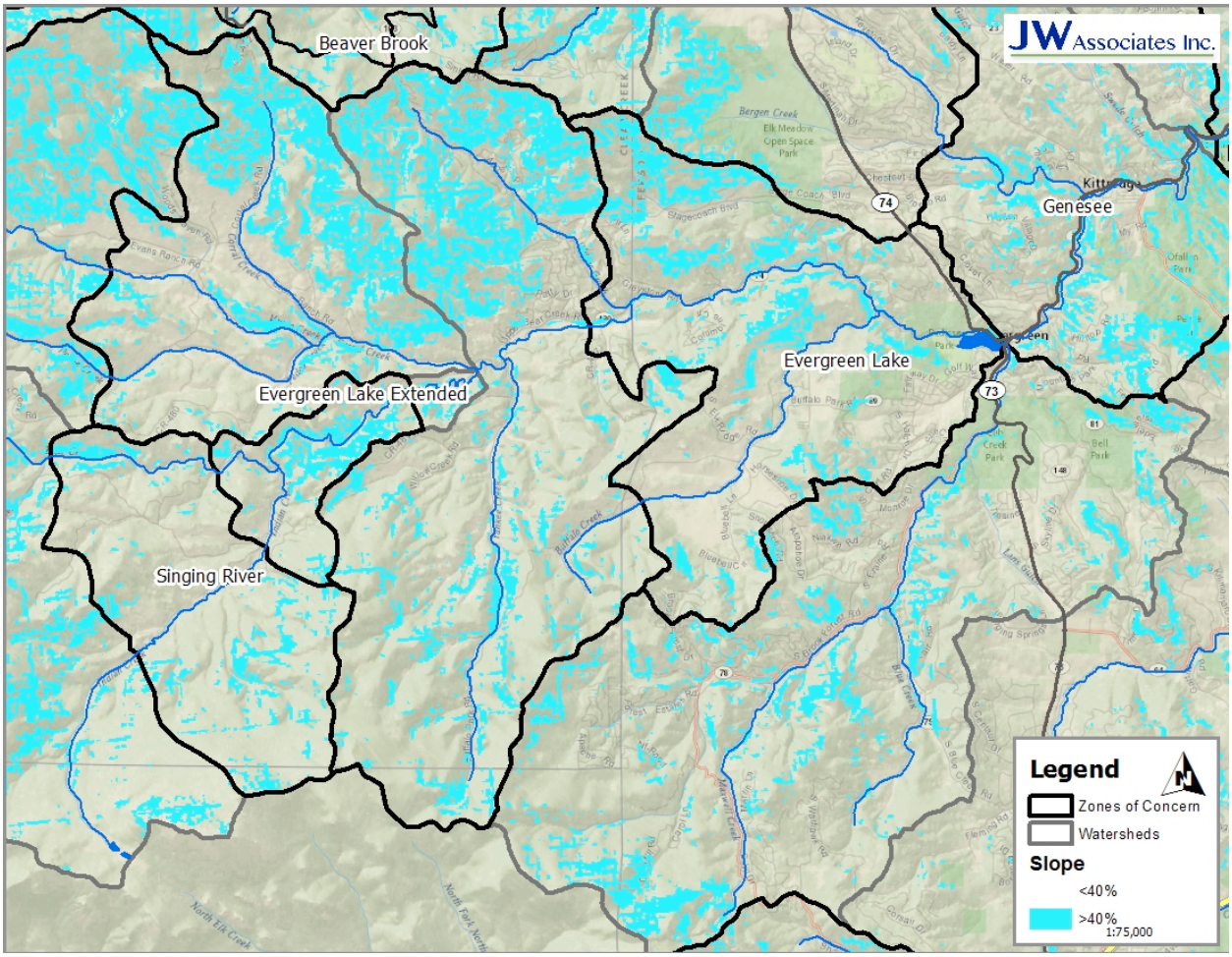


Figure 89. Evergreen Lake ZoC Slope

Evergreen Lake Special Management Areas

There are no special management areas in the Evergreen Lake ZoC and Evergreen Lake Extended ZoC (Figure 90). The Singing River ZoC contains portions of the Mount Evans Wilderness Area and Mount Evans Adjacent Roadless Area south of Indian Creek.

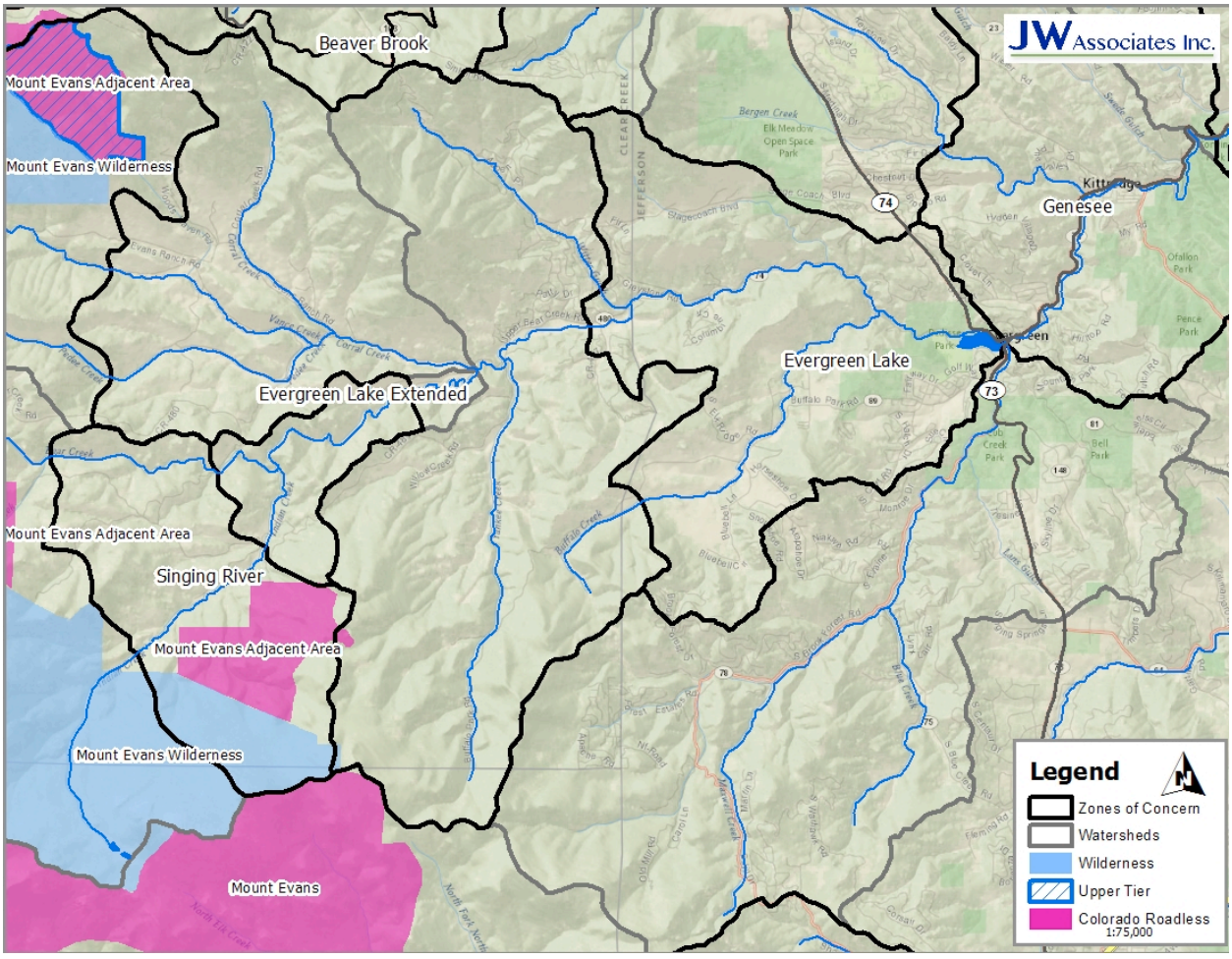


Figure 90. Evergreen Lake ZoC Special Areas

Evergreen Lake Vegetation

The Evergreen Lake ZoC is characterized by north-facing slopes that are generally dominated by Douglas-fir and south-facing slopes that are dominated by ponderosa pine mixed with Douglas-fir. There are some areas of aspen and sagebrush. The Evergreen Lake Extended ZoC is similar to the Evergreen Lake ZoC but transitions to aspen and some large areas of lodgepole pine at higher elevations. The Singing River ZoC contains mostly Douglas-fir at lower elevations and transitions to a mixture of lodgepole pine and aspen and finally spruce-fir at the highest elevations (Figure 91).

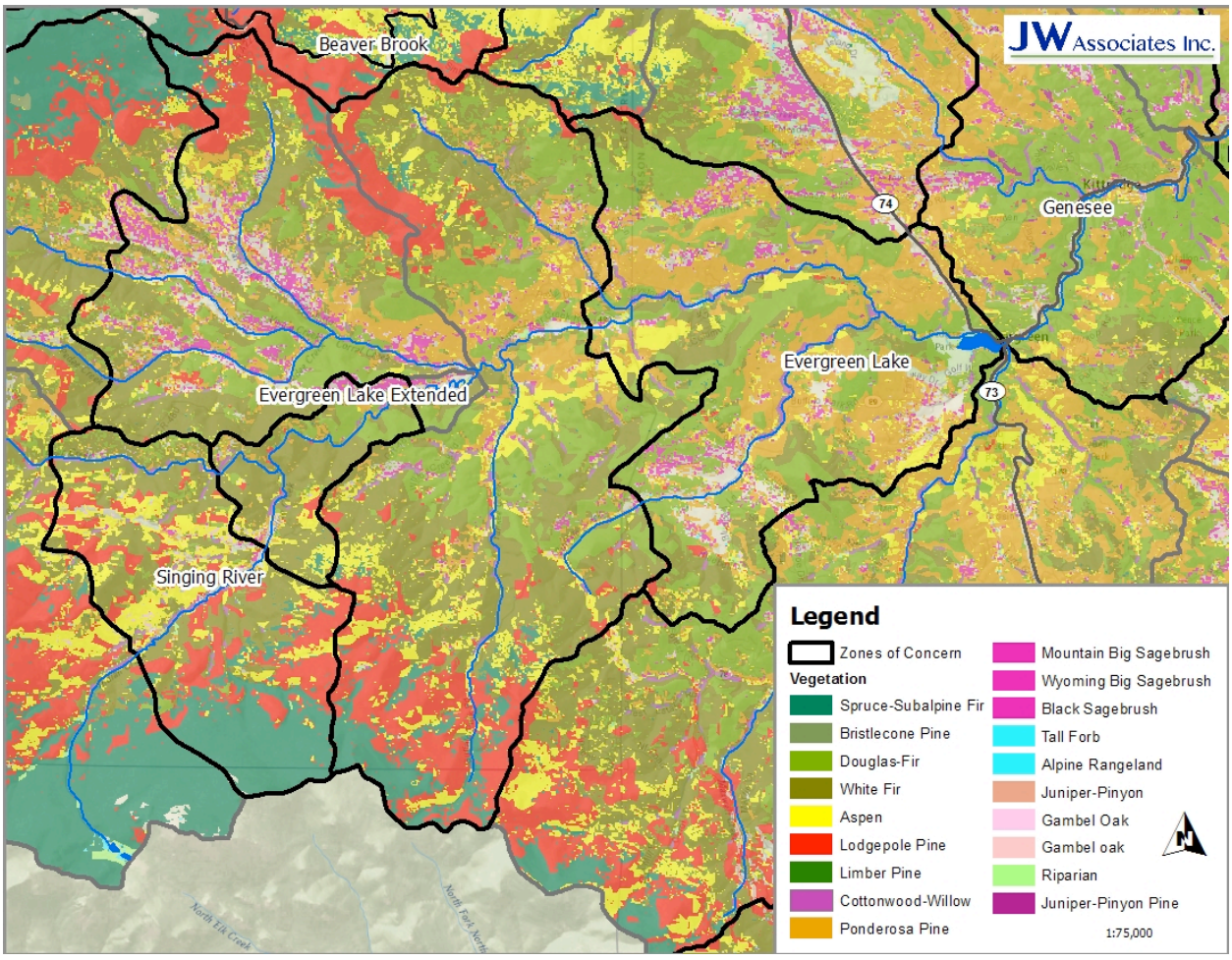


Figure 91. Evergreen Lake ZoC Vegetation

Evergreen Lake Access

There are numerous existing roads in most areas in the Evergreen Lake ZoC (Figure 92). The Evergreen Lake Extended ZoC also has numerous roads that provide access to many of the forested areas. The higher elevation and steeper areas in upper Corral Creek and Witter Gulch do not have existing access. The Singing River ZoC has some roads that provide access to some of the forested areas.

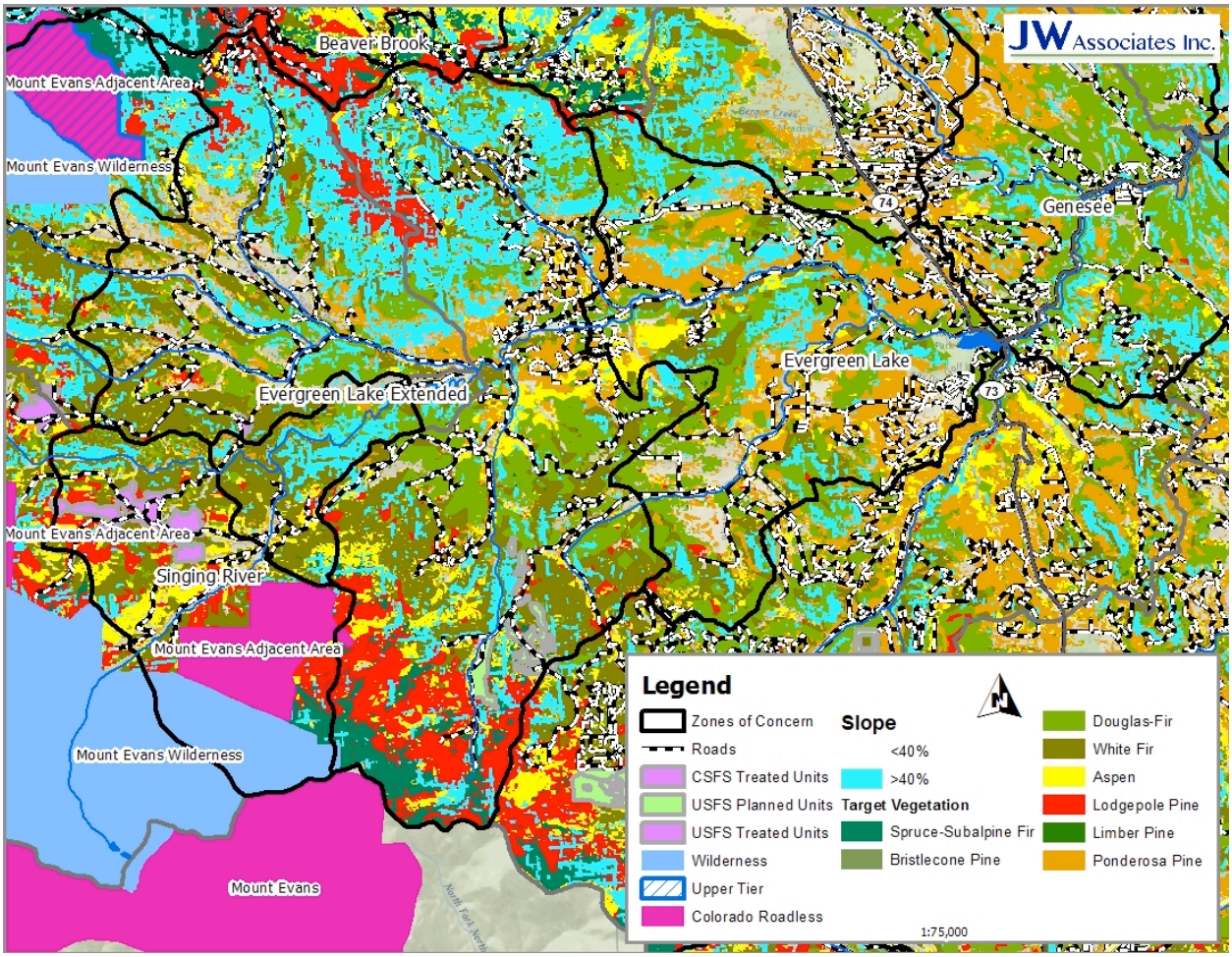
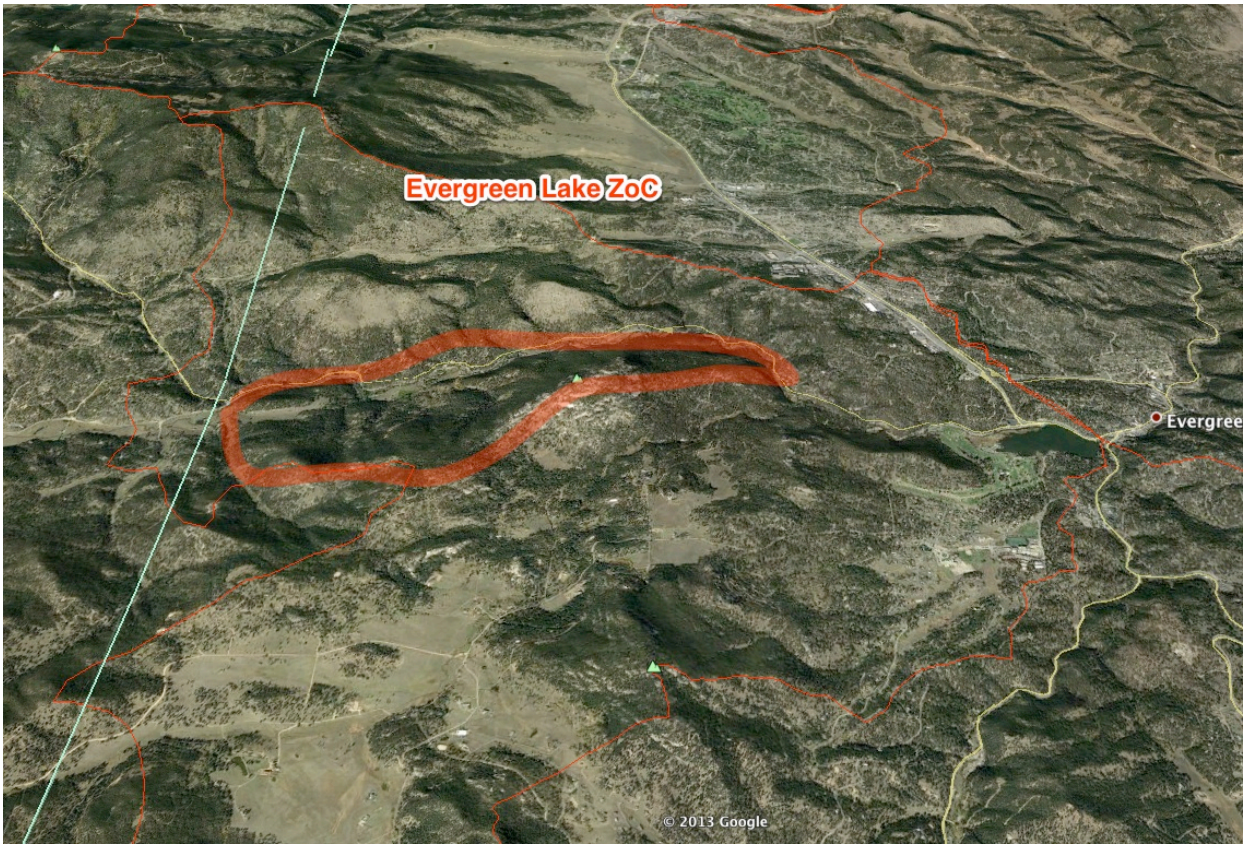


Figure 92. Evergreen Lake ZoC Opportunities

Evergreen Lake Opportunities

The Evergreen Lake ZoC has some opportunities. There are some opportunities on north-facing slopes that are densely forested and adjacent to Bear Creek. This area is all private lands which will make treatments more complex but there are a number of roads that provide access. Education and collaboration with the landowners will be critical in this ZoC. Treatments should include removal of Douglas-fir and restoration of ponderosa pine. In areas dominated by Douglas-fir, favor retention of ponderosa pine, remove most surface and ladder fuels, and prune residual trees to raise canopy height.



The Evergreen Lake Extended ZoC has many opportunities. There are many gulches and tributaries that should be analyzed at a finer scale to determine the highest priority. One example of a potential high priority tributary is Witter Gulch which is relatively steep and densely forested. Similar to the Evergreen Lake ZoC, there are numerous roads because of the amount of private lands. Therefore, education and collaboration with the landowners will be critical in this ZoC. Treatments should focus on restoration of ponderosa pine and greatly reducing densities of any invading Douglas-fir. In areas dominated by Douglas-fir, favor retention of ponderosa pine, remove most surface and ladder fuels, and prune residual trees to raise canopy height. There are some areas of lodgepole pine high in this ZoC. These may not be targets for treatments as they do not have good access. However, there may be some areas where aspen enhancement could be accomplished.

Lower Bear Creek ZoC

This section discusses the Lower Bear Creek, Idledale, Genesee, and Lower Turkey Creek ZoC because they are adjacent or overlapping (Figure 93). Note that the ZoC are shown here in blue shading, but in the remaining figures the outlines appear as bold black lines with no shading.

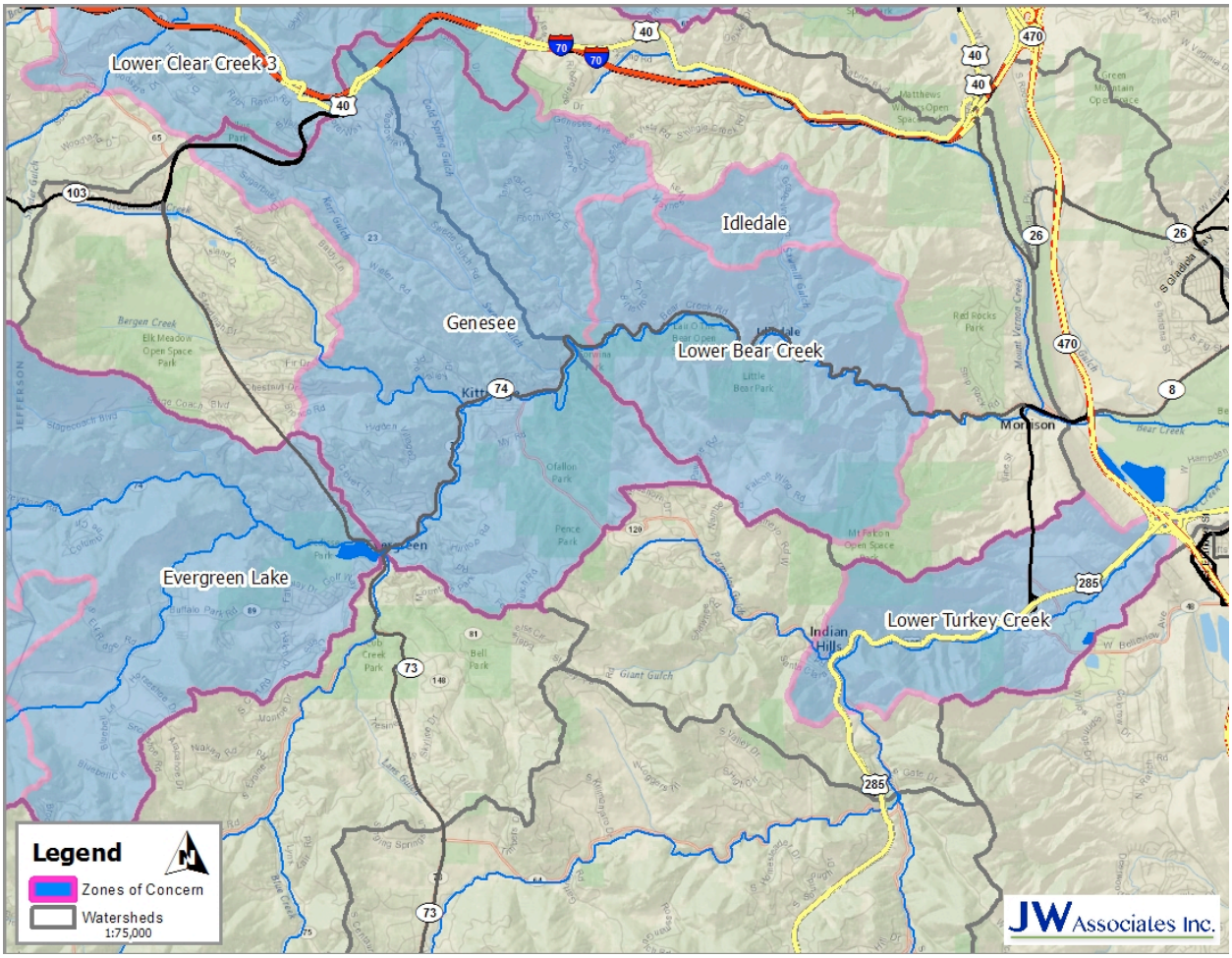


Figure 93. Lower Bear Creek ZoC Location

Lower Bear Creek Ownership

The Lower Bear Creek ZoC contains a large area of Jefferson County Open Space (Figure 94), including Lair o' the Bear Park, Matthews/Winters Park and Mount Falcon Park) and Little Park (Denver Mountain Parks). The remainder of the Lower Bear Creek ZoC is private land. The Idledale ZoC is entirely private land. The Genesee ZoC is mostly private land but also contains some Jefferson County Open Space, including Genesee Park, O'Fallon Park, Corwina Park and Pence Park. The Lower Turkey Creek ZoC is mostly private lands with some large areas of Jefferson County Open Space (Figure 94) including Mount Falcon Park.

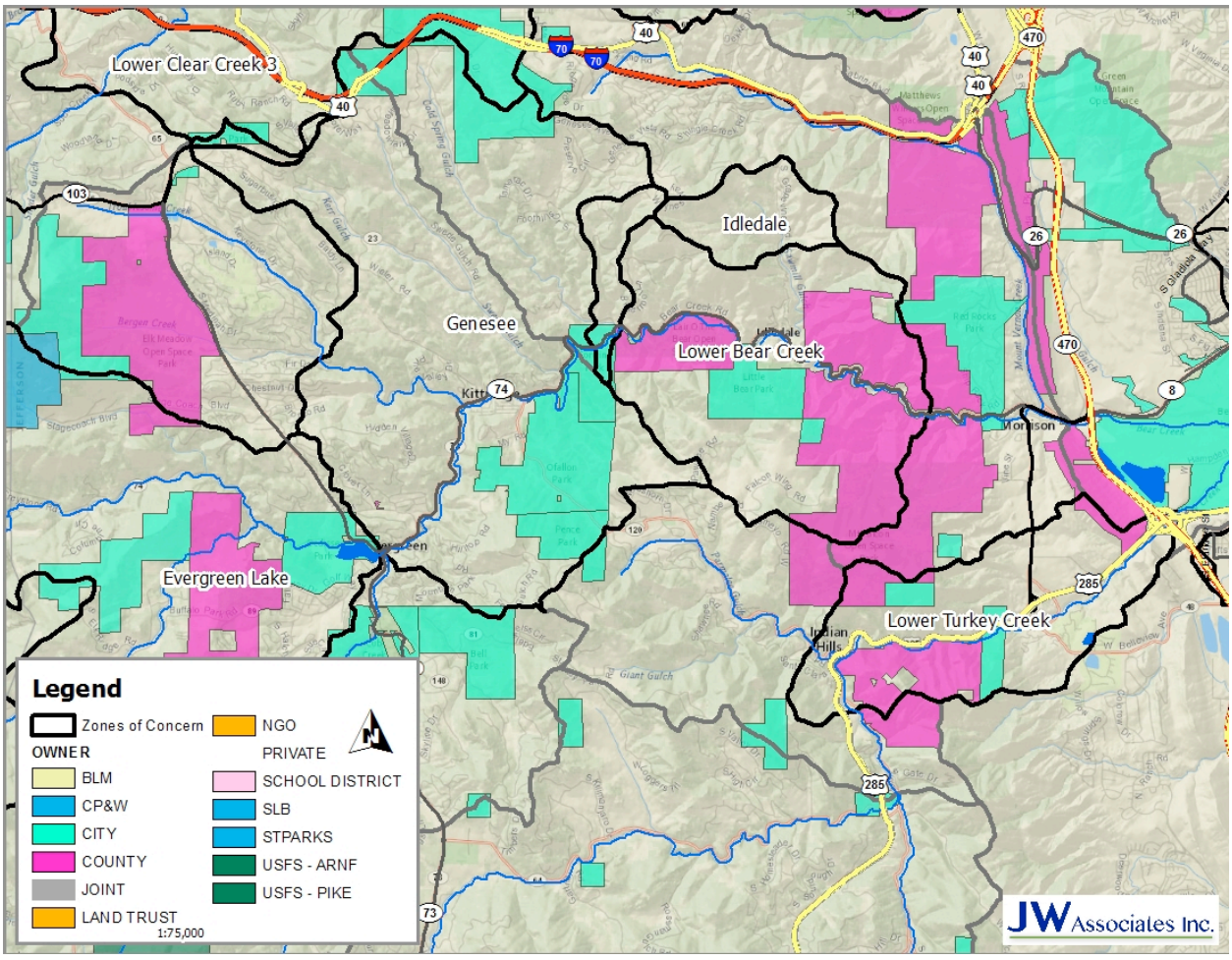


Figure 94. Lower Bear Creek ZoC Ownership

Lower Bear Creek Watershed Priority

The Lower Bear Creek ZoC, Idledale ZoC and Genesee ZoC are within the Mount Vernon Creek-Bear Creek watershed (Figure 95) that is ranked Green (Category 1 - lowest) overall. The Genesee ZoC is also within the Troublesome Creek-Bear Creek watershed that is ranked Green (Category 1 - lowest) overall and as Orange (Category 4) for Flooding/Debris Flow Hazard. The Lower Turkey Creek ZoC is within the Bear Creek Lake watershed that is ranked Green (Category 1 - lowest) overall (Figure 95).

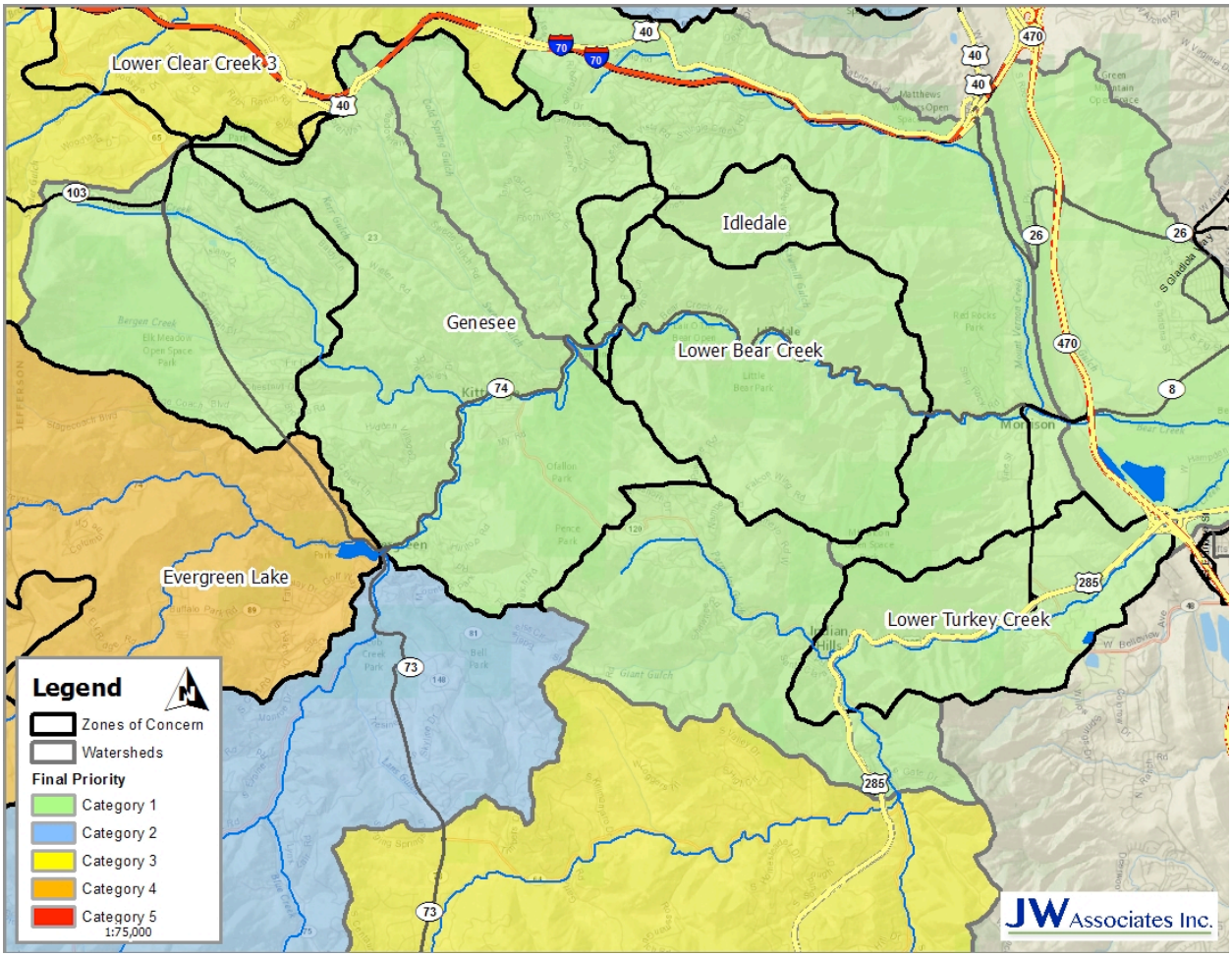


Figure 95. Lower Bear Creek ZoC Watershed Priority

Lower Bear Creek Slopes

The Lower Bear Creek ZoC is characterized by mostly steep slopes throughout (Figure 96) except for the extreme southern and northern portions that have shallower slopes. The Idledale ZoC has mostly shallow slopes. The Genesee ZoC also has mostly shallow slopes except for areas surrounding Troublesome Creek and Bear Creek below Evergreen Lake. The Lower Turkey Creek ZoC is characterized by mostly steep slopes in the western portions of the ZoC and shallower slopes in the eastern portions (Figure 96).

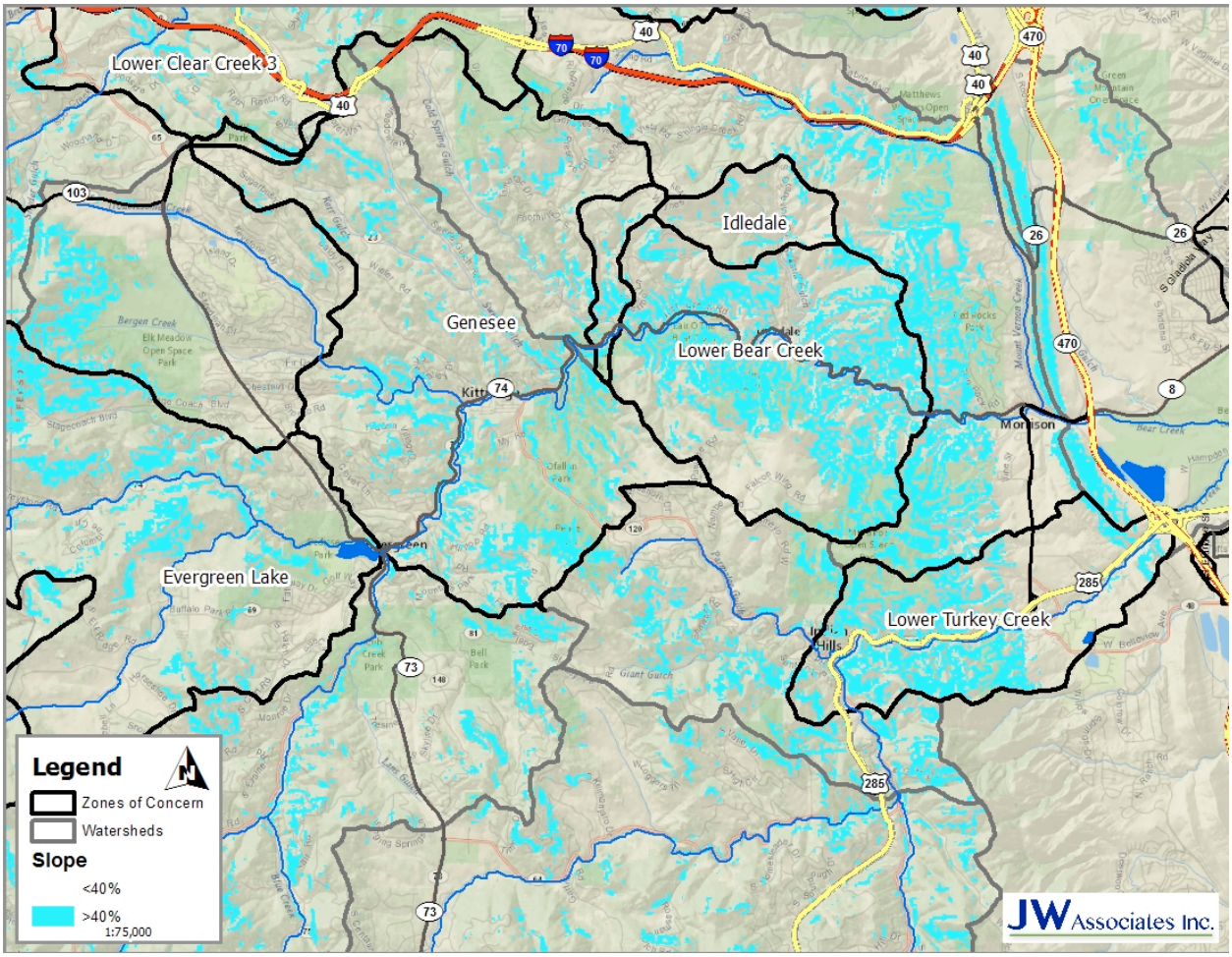


Figure 96. Lower Bear Creek ZoC Slope

Lower Bear Creek Special Management Areas

There are no special management areas in these ZoC (Figure 97).

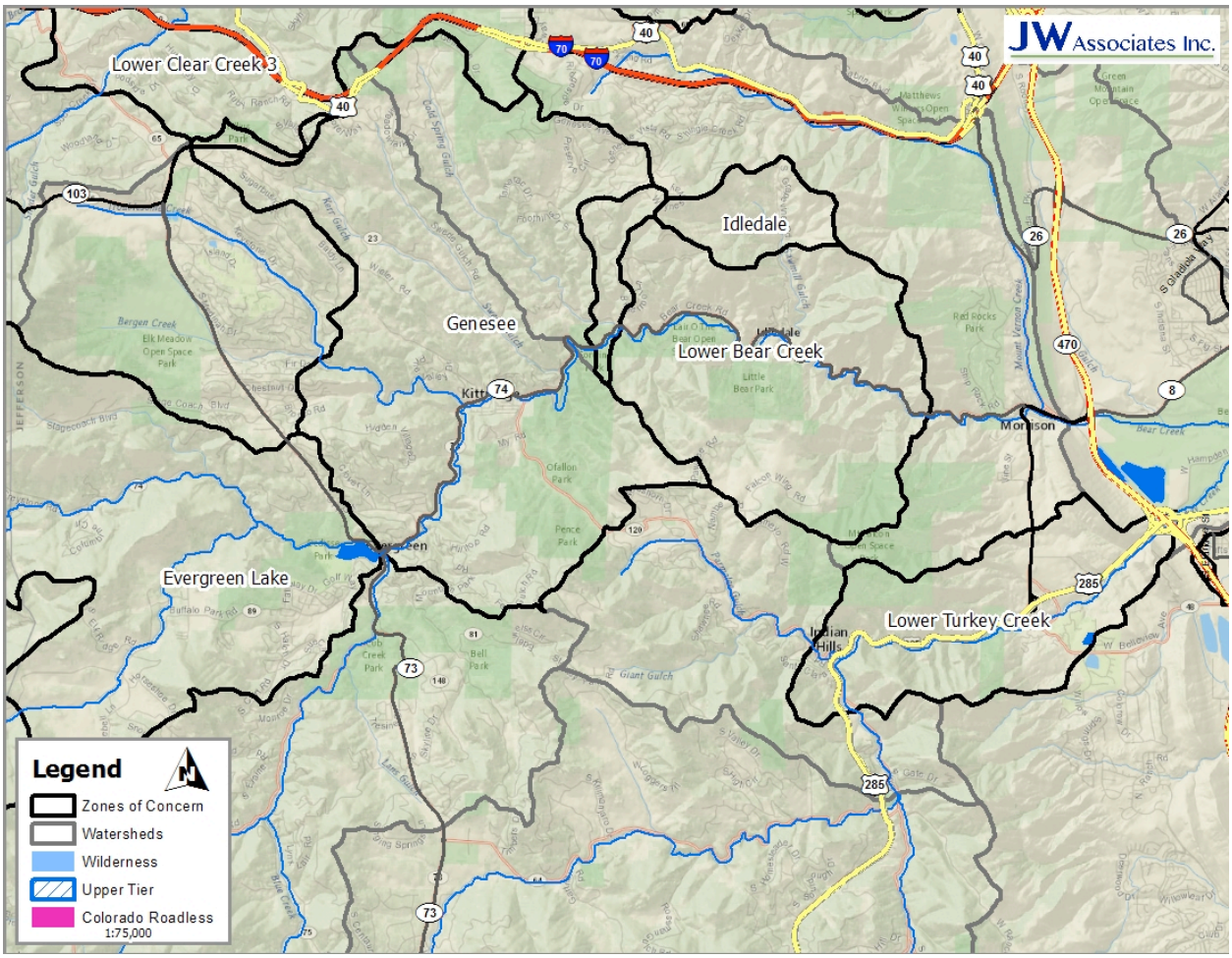


Figure 97. Lower Bear Creek ZoC Special Areas

Lower Bear Creek Vegetation

The Lower Bear Creek ZoC is characterized by north-facing slopes that are generally dominated by Douglas-fir and south-facing slopes that are dominated by ponderosa pine mixed with sagebrush (Figure 98). There are also some smaller areas of aspen in the Lower Bear Creek ZoC. The Idledale ZoC has areas of ponderosa pine, Douglas-fir and sagebrush. The Genesee ZoC has a large area of ponderosa pine in the northern portion and is dominated by Douglas-fir in a large area surrounding Bear Creek. The Lower Turkey Creek ZoC is mostly Douglas-fir in the western portion with areas of ponderosa pine in the eastern portion.

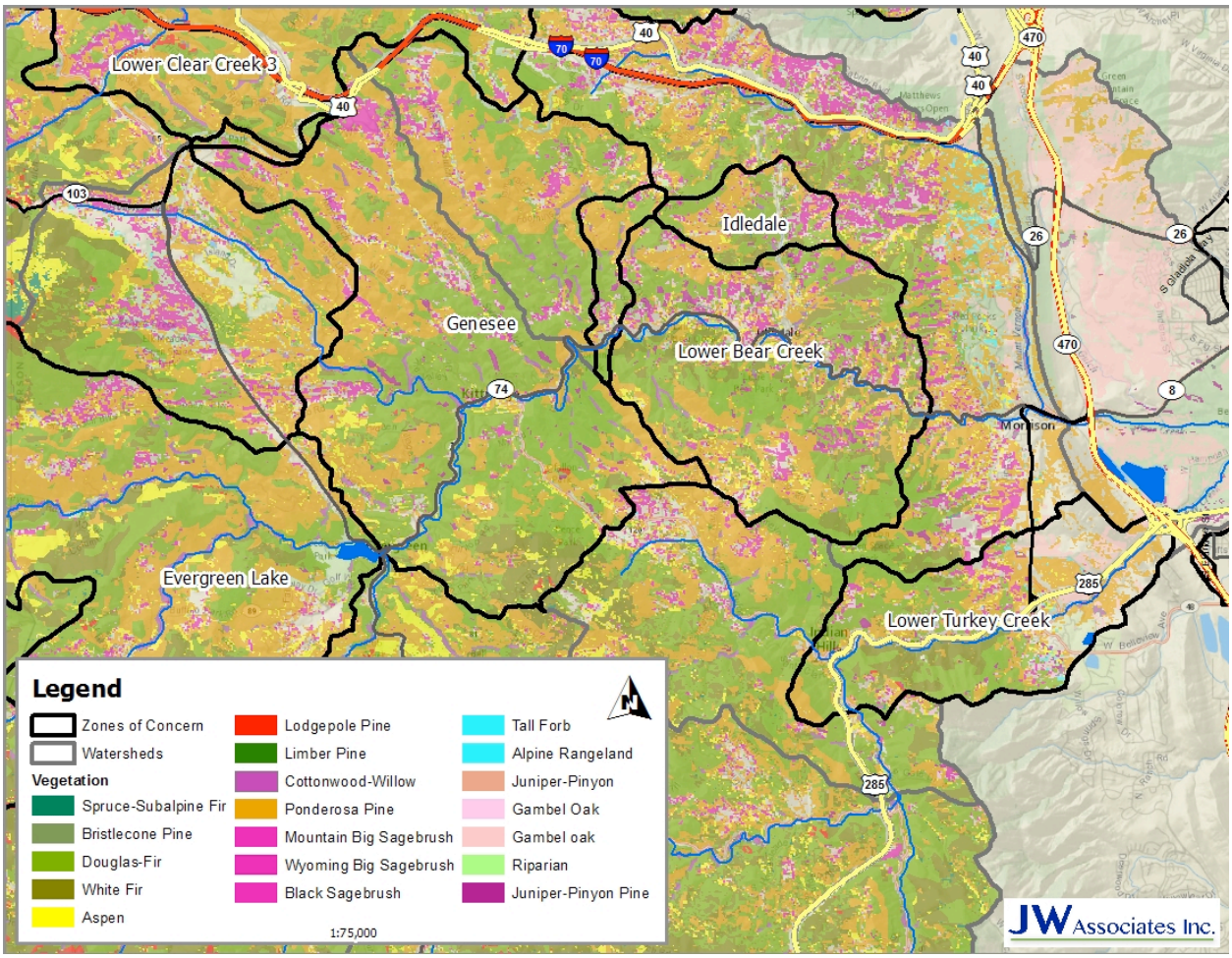


Figure 98. Lower Bear Creek ZoC Vegetation

Lower Bear Creek Access

Lower Bear Creek ZoC has only a few existing roads but they do access some of the forested areas that have shallower slopes (Figure 99). The Idledale ZoC has only one existing road, but due to its small size, this one road does provide some good access to forested areas. The Genesee ZoC has numerous existing roads that do provide access to many of the forested areas in this ZoC. The Lower Turkey Creek ZoC has only a few roads but they do provide some access to forested areas on shallower slopes (Figure 99).

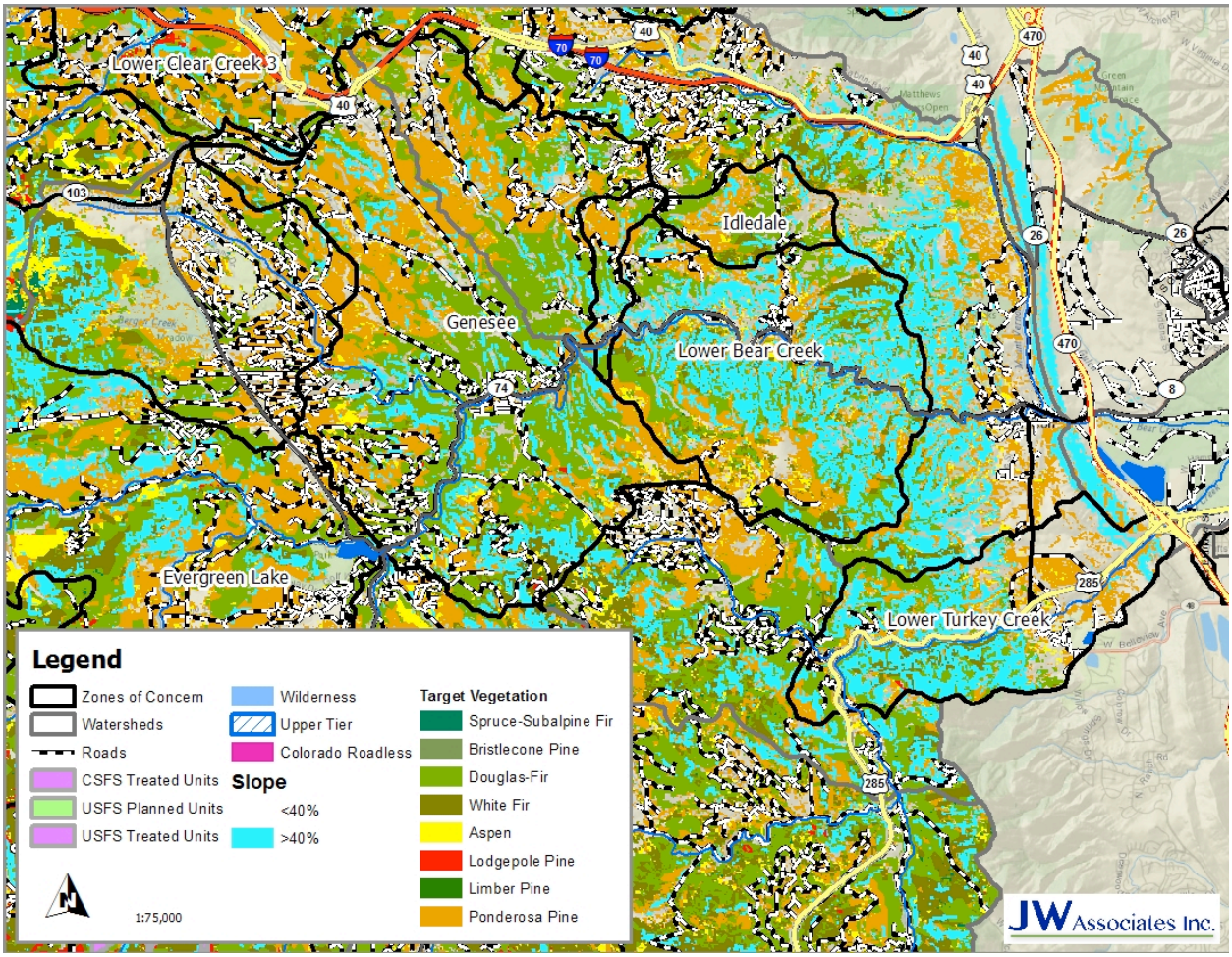
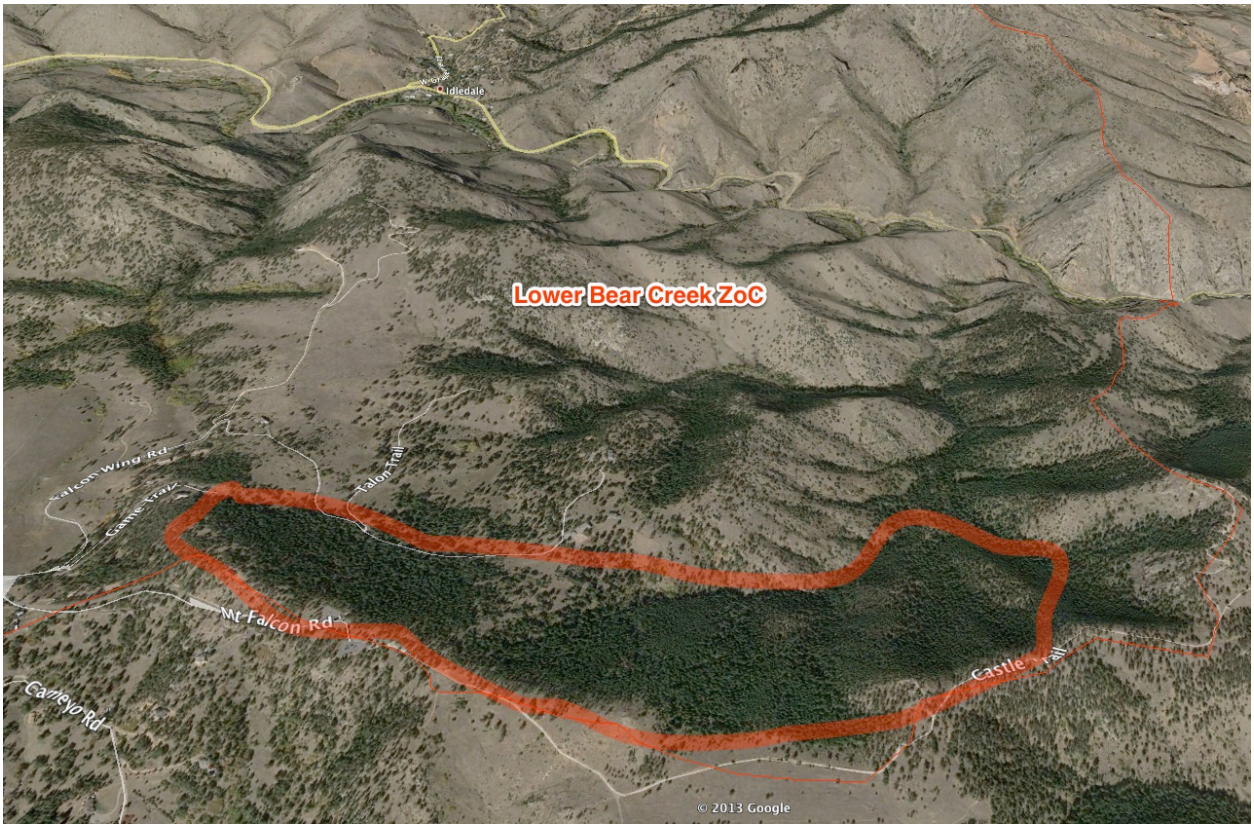


Figure 99. Lower Bear Creek ZoC Opportunities

Lower Bear Creek Opportunities

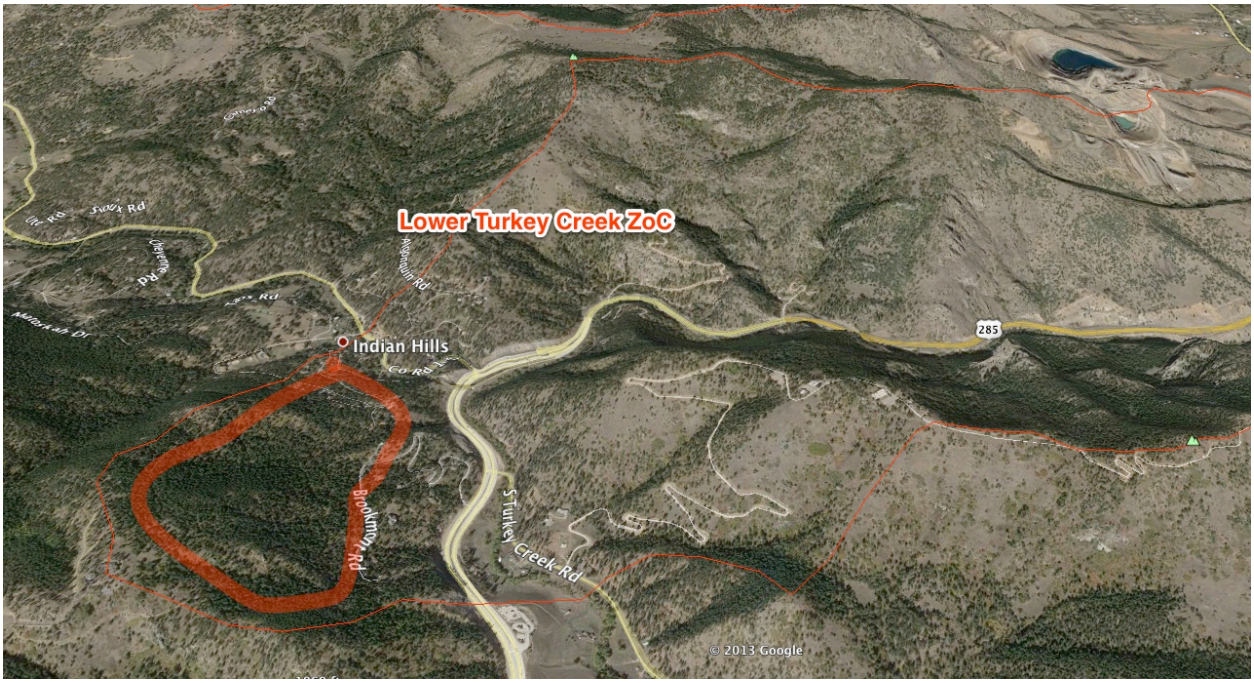
The Lower Bear Creek ZoC has limited opportunities due to steep slopes and lack of dense forest. However there is one area that has access to dense forest that would provide watershed protection. This area overlaps into Mount Falcon Park which is part of Jefferson County Open Space. Treatments in this area should focus on restoration of ponderosa pine and greatly reducing densities of any invading Douglas-fir. In areas dominated by Douglas-fir, favor retention of ponderosa pine, remove most surface and ladder fuels, and prune residual trees to raise canopy height.



The Idledale ZoC has only one area of dense forest and it lacks access. Most of this ZoC is relatively open forest land. Opportunities in this ZoC are limited.

The Genesee ZoC has many opportunities for forest treatments. The forest is relatively dense throughout this ZoC and the large amount of private lands provides access but makes treatments more complex. Additional analysis would be required to target specific areas for treatment because of the large areas or dense forest. Treatments should focus on restoration of ponderosa pine and greatly reducing densities of any invading Douglas-fir. In areas dominated by Douglas-fir, favor retention of ponderosa pine, remove most surface and ladder fuels, and prune residual trees to raise canopy height. Where aspen can be treated, enhancement or regeneration treatments would provide watershed benefits.

The Lower Turkey Creek ZoC has limited opportunities due to steep slopes, lack of access and mostly open forests. One area has the potential to be treated however it appears that access is limited and it is on private lands. There may be other opportunities in this ZoC but they would be small treatment areas.



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APPENDIX A

LIST OF CLEAR/BEAR CREEK WATERSHED STAKEHOLDERS

Table A-1. Clear/Bear Creek Watershed Stakeholders List

Organization	Last	First	Phone	email
Bear Creek Watershed Ass.	Clayshulte	Russell	303.751.7144	rclayshulte@earthlink.net
CDOT	Huyck	Holly	7204976934	holly.huyck@dot.state.co.us
City & County of Denver	Finch	Bob	720-913-0648	bob.finch@denvergov.org
City of Arvada	McCarthy	James	7208987765	jim-m@arvada.org
City of Arvada	Tohill	Kevin	720.898.7764	KTOHILL@arvada.org
City of Black Hawk	Ford	Jim	3035822237	JFord@CityofBlackHawk.org
City of Golden	Stambaugh	Will	3033848189	wstambaugh@cityofgolden.net
City of Golden	Beierle	Anne	303.384.8153	ABeierle@cityofgolden.net
City of Northglenn	Stanley	Shelley	303.450.4067	sstanley@northglenn.org
City of Thornton	Shih	Shay		Hsueh.Shih@cityofthornton.net
City of Westminster	Fabisiak	Mary	3036582187	mfabisiak@cityofwestminster.us
City of Westminster	Shugarts	Cathy	3036582462	cshugarts@cityofwestminster.us
Clear Creek County	Hyatt	Trent	3036792362	thyatt@co.clear-creek.co.us
Clear Creek County	Weaver	Bert		bweaver@co.clear-creek.co.us
Clear Creek County	Sorensen	JoAnn		jsorensen@co.clear-creek.co.us
Clear Creek Watershed Foundation	Crouse	Christine	303.567.2699	Christine.Crouse@colostate.edu
Colorado State Forest Service	Edwards	Rich	970.213.8619	rich.edwards@colostate.edu
Denver Mountain Parks	Perry	Andy	7209131311	parksandrecreation@denvergov.org
Evergreen Metro	Lighthart	Dave	3033015512	dlighthart@evergreenmetrodistrict.com
Evergreen Metro	Schauder	Chris	303-674-4120	cschauder@evergreenmetrodistrict.com
Evergreen Metro Dist	Schulte	Gerry	303.674.4112	gschulte@evergreenmetrodistrict.com
Jefferson Conservation District	Devine	Brian		Brian.devin@co.nacdnet.net
Jefferson Conservation District	Hansen	Joseph	720.544.2872	joseph.hansen@co.nacdnet.net
Jefferson County	O'Connell	Pat		poconnel@jeffco.us
MillerCoors LLC	Templeton	Audrey	414.931.2409	Audrey.Templeton@millercoors.com
Molson Coors Brewing Company	Moline	Ben	303 927 3680	ben.moline@molsoncoors.com
Natural Resources Conservation Service	Feinstein	Jonas	720.544.2839	jonas.feinstein@co.usda.gov
The Consolidated Mutual Water Company	Jones	Chris	(303)274-7410	cjones@cmwc.net
Upper Clear Creek Watershed Association	Adams	Phyllis		uccwa@live.com
US Forest Service	Lovato	Daniel		dlovato@fs.fed.us
US Forest Service	Hutchinson	Cody	303.541.2512	crhutchinson@fs.fed.us
US Forest Service	von der Ohe	Andrea	3035673001	avonderohe@fs.fed.us
US Forest Service - Arapaho Roosevelt NF	Gibbs	Hal	970.295.6630	hdgibbs@fs.fed.us
US Forest Service - Arapaho Roosevelt NF	Chambers	Carl	970.295.6633	cchambers@fs.fed.us
US Forest Service - Regional Office	Harper	Claire	303.275.5178	claireharper@fs.fed.us
Xcel Energy	Johnston	Christine	3032942224	christine.johnston@xcelenergy.com

APPENDIX B

CLEAR/BEAR CREEK WILDFIRE HAZARD MODELING METHODOLOGY

The forest conditions that are of concern for the assessments are the wildfire hazard based on existing forest conditions. The wildfire hazard (Flame Length) was determined using the Fire Behavior Assessment Tool (FBAT) (http://www.fire.org) which is an interface between ArcMap and FlamMap. The input spatial data were collected from LANDFIRE project (http://www.landfire.gov/).

After a mountain pine beetle outbreak there are substantial increases in the amount of fine dead fuels in the canopy. The majority of these fuels remain in the canopy for 2-3 years post outbreak (Knight 1987, Schmid and Amman 1992). Therefore, certain input spatial data sets were updated reflecting Mountain Pine Beetle (MPB) mortality conditions using USDA Forest Service, Rocky Mountain Region Aerial Detection Survey (ADS) Data from the years 2002 - 2007 (http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/). The following modeling settings and spatial data modification were used:

Modeling Setting

1. Scott and Burgan (2005) Fire Behavior Model (Fuel Moisture is shown in Table A-1)
2. Uphill wind direction
3. Scott & Reinhardt (2001) crown fire calculation
4. Foliar Moisture at 100%

Spatial Data Modifications

1. Canopy Cover was assigned a value of 10% when coincident with MPB mortality from ADS for years 2002-2007.
2. Canopy Base Height (CBH) was reduced by 25% for MPB mortality derived from ADS for the years 2002-2006.
3. CBH was reassigned a value of 0 for MPB mortality from ADS for the year 2007.
4. Canopy Bulk Density (CBD) was reduced by 50% for MPB mortality derived from ADS for the years 2002-2006

Table B-1. Fuel Moisture (percent) used in FBAT Model Runs

Scott and Burgan (2005) fuel model	1-Hour Fuel	10-Hour Fuel	100-Hour Fuel	Live Herbaceous	Live Woody
1	4	5	8	200	95
2	4	5	8	150	95
3	4	5	8	85	95
4	4	5	8	85	95
5	4	5	8	85	150
6	4	5	8	85	95
7	4	5	8	85	95
8	4	5	8	85	95
9	4	5	8	85	95
10	4	5	8	85	95
11	4	5	8	85	95
12	4	5	8	85	95
13	4	5	8	85	95
14	3	4	8	85	95
15	3	4	8	85	95
16	3	4	8	85	95
17	3	4	8	85	95
18	3	4	8	85	95
19	3	4	8	85	95
20	3	4	8	85	95
21	3	4	8	85	95
22	3	4	8	85	95
23	3	4	8	85	95
24	3	4	8	85	95
25	3	4	8	85	95
26	3	4	8	85	95
27	3	4	8	85	95
28	3	4	8	85	95
29	3	4	8	85	95
30	3	4	8	85	95
31	3	4	8	85	95
32	3	4	8	85	95
33	3	4	8	85	95
34	3	4	8	85	95
35	3	4	8	85	95
36	3	4	8	85	95
37	3	4	8	85	95
38	3	4	8	85	95
39	3	4	8	85	95
40	3	4	8	85	95
41	3	4	8	85	95
42	3	4	8	85	95
43	3	4	8	85	95
44	3	4	8	85	95
45	3	4	8	85	95
46	3	4	8	85	95
47	3	4	8	85	95
48	3	4	8	85	95
49	3	4	8	85	95
50	3	4	8	85	95

Weather Data

The weather data used comes from the Colorado Wildfire Risk Assessment Statewide (CRA) dataset prepared by Sandborn under contract to the Colorado State Forest Service. For the Colorado Fire Risk Assessment nine weather influence zones (WIZ) were developed for analysis purposes. A WIZ is an area where for analysis purposes the weather on any given day is uniform. Within each WIZ, daily weather data was gathered for the years 1980-2006. Where not available, the weather data was gathered from the earliest year through 2006. Several weather stations were analyzed within each WIZ. From this analysis, one representative weather station was selected for each WIZ. From this data set, percentile weather was developed for each WIZ using the Fire Family Plus software package.

For this watershed assessment the percentile weather for WIZ CO 02 (Dowd 1986-2006) was used for all watersheds on the west side of the continental divide and WIZ CO 03 (Coral Creek 1980-2006) was used for all watersheds on the east side of the continental divide. The 20-foot wind speeds for the "High" case was used in the modeling runs (Table B-2).

In addition the wind direction was assumed to be uphill (parallel with slope) in all instances. This setting encourages crown fire initiation and establishes a common baseline for the evaluation of areas within the landscape based upon the fuels hazard represented by vegetation conditions.

Table B-2. Wind Speed (Miles per Hour) used in FBAT Model Runs

Watershed Name	Wind Speed (mph)	Probable Momentary Gust Speed (mph)
North Platte	15	29
Upper North Platte	15	29
Crow/Medicine Bow/Upper Laramie/Upper Lodgepole	12	25
Clear/Bear Creek	12	25
Big Thompson	12	25
Cache la Poudre	12	25
Blue River	15	29
Eagle River	15	29
Upper Yampa	15	29
Little Snake	15	29
Upper White	15	29
Lower Colorado	15	29
Upper Colorado	15	29
Saint Vrain	12	25
Roaring Fork	15	29

Categorization of Results

The FBAT model results were divided into five categories of flame length. These values range from lowest (Category 0) to highest (Category 4) based upon flame length. The flame length categories that were used are:

Flame Length Category 0 - 0 meters

Flame Length Category 1 - 1 to 10 meters

Flame Length Category 2 - 11 to 25 meters

Flame Length Category 3 - 26 to 40 meters

Flame Length Category 4 - >40 meters

APPENDIX C

DETAILED CLEAR/BEAR CREEK WATERSHED ASSESSMENT RESULTS

Table C-1. Clear/Bear Creek Watershed Wildfire Hazard Ranking[1]

Sixth-level Watershed Name	Watershed Area (acres)	Wildfire Hazard Calculation	Wildfire Hazard Rank
Soda Creek	8,941	57.0%	5.5
Outlet Chicago Creek	12,142	56.0%	5.4
Upper Ralston Creek	20,615	55.4%	5.3
Silver Gulch-Clear Creek	5,260	50.5%	4.6
Cub Creek	14,241	54.2%	5.1
Evergreen Lake-Bear Creek	20,431	52.2%	4.9
Mill Creek-Clear Creek	12,696	52.9%	5.0
Turkey Creek	24,197	53.2%	5.0
City of Idaho Springs-Clear Creek	14,457	49.2%	4.5
Vance Creek	18,559	45.4%	3.9
North Clear Creek	38,491	43.3%	3.7
Beaver Brook-Clear Creek	26,222	40.5%	3.3
Middle Ralston Creek	8,973	38.7%	3.0
Headwaters West Chicago Creek	18,607	36.4%	2.7
West Fork Clear Creek	36,752	36.7%	2.8
Headwaters Bear Creek	28,652	33.7%	2.4
Fall River	14,976	31.8%	2.1
Troublesome Creek-Bear Creek	12,667	34.3%	2.4
Mount Vernon Creek-Bear Creek	17,719	30.6%	2.0
Clear Creek Canyon	26,281	29.1%	1.7
Headwaters Clear Creek	30,846	27.0%	1.5
Bear Creek Lake	14,445	23.4%	1.0
South Clear Creek	19,295	19.8%	0.5
Van Bibber Creek	11,357	21.0%	0.7

[1] The watershed highlighted by shaded gray was adjusted because it was skewing the categorization

Table C-2. Clear/Bear Creek Watershed Ruggedness Ranking[2, 3, 4]

Sixth-level Watershed Name	Maximum Elevation	Minimum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank
Silver Gulch-Clear Creek	12,297	8,220	4,077	0.2400	5.5
Mill Creek-Clear Creek	13,133	7,721	5,412	0.2301	5.1
Fall River	13,353	7,708	5,645	0.2210	4.8
Outlet Chicago Creek	11,555	7,554	4,002	0.2131	4.5
Soda Creek	11,637	7,518	4,120	0.2088	4.4
City of Idaho Springs-Clear Creek	11,122	6,914	4,208	0.2054	4.2
Van Bibber Creek	9,738	5,340	4,398	0.1978	4.0
Headwaters Bear Creek	14,232	7,521	6,711	0.1900	3.7
Beaver Brook-Clear Creek	11,467	6,393	5,074	0.1839	3.4
Middle Ralston Creek	8,994	6,032	2,962	0.1835	3.4
South Clear Creek	13,809	8,502	5,307	0.1831	3.4
Vance Creek	12,736	7,544	5,192	0.1826	3.4
Troublesome Creek-Bear Creek	9,692	6,708	2,985	0.1797	3.3
Headwaters West Chicago Creek	13,674	8,804	4,871	0.1711	3.0
Evergreen Lake-Bear Creek	10,571	7,055	3,516	0.1667	2.8
Headwaters Clear Creek	14,229	8,505	5,724	0.1561	2.4
North Clear Creek	12,133	6,914	5,218	0.1561	2.4
Clear Creek Canyon	9,925	5,619	4,307	0.1559	2.4
Cub Creek	10,696	7,032	3,664	0.1471	2.1
Bear Creek Lake	8,554	5,550	3,004	0.1467	2.1
West Fork Clear Creek	13,632	8,230	5,402	0.1350	1.7
Turkey Creek	10,693	6,858	3,834	0.1181	1.0
Mount Vernon Creek-Bear Creek	8,262	5,733	2,529	0.1115	0.8
Upper Ralston Creek	10,489	7,396	3,093	0.1032	0.5

[2] Ruggedness is based on Melton (1957)

[3] The watersheds highlighted in green were manually adjusted because they do not accurately reflect the ruggedness in those watersheds.

[4] The watershed highlighted in gray was adjusted because it was skewing the categorization

Table C-3. Clear/Bear Creek Watershed Road Density Ranking[5]

Sixth-level Watershed Name	Roads (miles)	Roads Adjusted (miles)	Watershed Area (sq. mi.)	Road density (miles per sq. mi.)	Road Density Rank
Mill Creek-Clear Creek	101.7	101.7	19.84	5.13	5.5
Cub Creek	112.4	112.4	22.25	5.05	5.4
Turkey Creek	182.5	182.5	37.81	4.83	5.2
Soda Creek	65.6	65.6	13.97	4.69	5.0
Outlet Chicago Creek	87.4	87.4	18.97	4.60	4.9
Mount Vernon Creek-Bear Creek	123.8	123.8	27.69	4.47	4.8
City of Idaho Springs-Clear Creek	128.8	96.6	22.59	4.28	4.6
Fall River	98.5	98.5	23.40	4.21	4.5
Troublesome Creek-Bear Creek	120.0	80.4	19.79	4.06	4.3
Bear Creek Lake	130.5	87.4	22.57	3.87	4.1
Beaver Brook-Clear Creek	158.1	158.1	40.97	3.86	4.1
Evergreen Lake-Bear Creek	119.6	119.6	31.92	3.74	4.0
Clear Creek Canyon	148.9	148.9	41.06	3.63	3.8
North Clear Creek	211.0	211.0	60.14	3.51	3.7
Silver Gulch-Clear Creek	42.1	28.2	8.22	3.43	3.6
Van Bibber Creek	91.3	45.6	17.75	2.57	2.7
West Fork Clear Creek	145.7	145.7	57.43	2.54	2.6
South Clear Creek	67.4	67.4	30.15	2.24	2.3
Upper Ralston Creek	71.1	71.1	32.21	2.21	2.3
Headwaters Clear Creek	116.7	87.5	48.20	1.82	1.8
Vance Creek	47.4	47.4	29.00	1.63	1.6
Headwaters West Chicago Creek	38.4	38.4	29.07	1.32	1.3
Middle Ralston Creek	14.2	14.2	14.02	1.01	0.9
Headwaters Bear Creek	28.3	28.3	44.77	0.63	0.5

[5] In the watersheds shaded in green, the road density was adjusted based upon the procedure discussed in the report.

Table C-4. Clear/Bear Creek Watershed Flooding/Debris Flow Hazard Ranking

Sixth-level Watershed Name	Ruggedness Ranking	Road Density Ranking	Combined Numeric Rank	Combined Ranking
Mill Creek-Clear Creek	5.1	5.5	15.00	5.5
Silver Gulch-Clear Creek	5.5	3.6	14.61	5.3
Fall River	4.8	4.5	14.09	5.1
Outlet Chicago Creek	4.5	4.9	13.95	5.1
Soda Creek	4.4	5.0	13.73	5.0
City of Idaho Springs-Clear Creek	4.2	4.6	13.02	4.7
North Clear Creek	2.4	3.7	11.07	3.8
Beaver Brook-Clear Creek	3.4	4.1	10.99	3.8
Troublesome Creek-Bear Creek	3.3	4.3	10.91	3.8
Van Bibber Creek	4.0	2.7	10.57	3.6
Cub Creek	2.1	5.4	9.63	3.2
Evergreen Lake-Bear Creek	2.8	4.0	9.60	3.2
Headwaters Clear Creek	2.4	1.8	9.19	3.0
South Clear Creek	3.4	2.3	9.12	3.0
Clear Creek Canyon	2.4	3.8	8.68	2.8
Vance Creek	3.4	1.6	8.42	2.7
Bear Creek Lake	2.1	4.1	8.28	2.6
Headwaters Bear Creek	3.7	0.5	7.84	2.5
Middle Ralston Creek	3.4	0.9	7.79	2.4
Turkey Creek	1.0	5.2	7.25	2.2
Headwaters West Chicago Creek	3.0	1.3	7.23	2.2
Mount Vernon Creek-Bear Creek	0.8	4.8	6.37	1.8
West Fork Clear Creek	1.7	2.6	5.94	1.6
Upper Ralston Creek	0.5	2.3	3.25	0.5

Table C-5. Clear/Bear Creek Watershed Soil Erodibility Ranking[6,7,8]

Sixth-level Watershed Name	Severe (%)	Very Severe (%)	Soil Erodibility Value	Soil Erodibility Rank
Silver Gulch-Clear Creek	21.2%	42.1%	0.730	5.5
Vance Creek	25.6%	13.5%	0.726	5.5
Mill Creek-Clear Creek	24.5%	17.7%	0.598	4.4
City of Idaho Springs-Clear Creek	28.0%	15.6%	0.591	4.3
West Fork Clear Creek	22.4%	17.9%	0.582	4.3
Headwaters Clear Creek	17.2%	16.7%	0.507	3.6
Headwaters Bear Creek	17.6%	4.7%	0.469	3.3
Soda Creek	29.2%	8.8%	0.468	3.3
Outlet Chicago Creek	29.5%	8.6%	0.466	3.3
South Clear Creek	17.2%	14.0%	0.452	3.2
Evergreen Lake-Bear Creek	13.2%	5.7%	0.445	3.1
Fall River	20.9%	7.4%	0.357	2.4
Headwaters West Chicago Creek	20.7%	6.7%	0.340	2.3
Cub Creek	9.6%	2.0%	0.336	2.2
North Clear Creek	18.9%	7.2%	0.334	2.2
Middle Ralston Creek	19.4%	6.4%	0.321	2.1
Clear Creek Canyon	20.3%	5.3%	0.309	2.0
Beaver Brook-Clear Creek	17.2%	6.8%	0.308	2.0
Turkey Creek	6.0%	1.4%	0.288	1.8
Upper Ralston Creek	15.1%	5.7%	0.264	1.6
Mount Vernon Creek-Bear Creek	14.1%	5.0%	0.240	1.4
Troublesome Creek-Bear Creek	11.1%	3.0%	0.170	0.9
Bear Creek Lake	12.3%	2.2%	0.166	0.8
Van Bibber Creek	7.8%	2.5%	0.128	0.5

[6] Soil Erodibility Value is percentage of Severe plus 2 times the percentage of Very Severe.

[7] The watershed shaded in gray was skewing the categorization and was adjusted.

[8] The watersheds shaded in green were adjusted because they contain granitic parent material

Table C-6. Clear/Bear Creek Watershed Composite Hazard Ranking

Sixth-level Watershed Name	Wildfire Hazard Rank	Flooding/ Debris Flow Rank	Soil Erodibility Rank	Composite Hazard Rank
Silver Gulch-Clear Creek	4.6	5.3	5.5	5.5
Mill Creek-Clear Creek	5.0	5.5	4.4	5.2
Soda Creek	5.5	5.0	3.3	4.7
Outlet Chicago Creek	5.4	5.1	3.3	4.7
City of Idaho Springs-Clear Creek	4.5	4.7	4.3	4.6
Vance Creek	3.9	2.7	5.5	4.0
Evergreen Lake-Bear Creek	4.9	3.2	3.1	3.6
Cub Creek	5.1	3.2	2.2	3.3
North Clear Creek	3.7	3.8	2.2	2.9
Fall River	2.1	5.1	2.4	2.8
Beaver Brook-Clear Creek	3.3	3.8	2.0	2.6
Turkey Creek	5.0	2.2	1.8	2.6
West Fork Clear Creek	2.8	1.6	4.3	2.4
Headwaters Bear Creek	2.4	2.5	3.3	2.2
Headwaters Clear Creek	1.5	3.0	3.6	2.2
Middle Ralston Creek	3.0	2.4	2.1	1.9
Upper Ralston Creek	5.3	0.5	1.6	1.8
Headwaters West Chicago Creek	2.7	2.2	2.3	1.7
Troublesome Creek-Bear Creek	2.4	3.8	0.9	1.7
South Clear Creek	0.5	3.0	3.2	1.5
Clear Creek Canyon	1.7	2.8	2.0	1.5
Mount Vernon Creek-Bear Creek	2.0	1.8	1.4	0.8
Van Bibber Creek	0.7	3.6	0.5	0.6
Bear Creek Lake	1.0	2.6	0.8	0.5

Table C-7. Clear/Bear Creek Watershed Water Supply Ranking

Sixth-level Watershed Name	Sources & Diversions	Reservoirs	Water Ranking
Vance Creek	0		0
Headwaters Bear Creek	1		1
Evergreen Lake-Bear Creek	1		1
Cub Creek	0		0
Troublesome Creek-Bear Creek	0		0
Mount Vernon Creek-Bear Creek	1		1
Turkey Creek	1		1
Bear Creek Lake	1		1
South Clear Creek	1		1
Headwaters Clear Creek	1		1
West Fork Clear Creek	1		1
Silver Gulch-Clear Creek	0	1	1
Fall River	0		0
Mill Creek-Clear Creek	1		1
Headwaters West Chicago Creek	0		0
Outlet Chicago Creek	1		1
Soda Creek	1		1
North Clear Creek	1		1
City of Idaho Springs-Clear Creek	1		1
Upper Ralston Creek	0		0
Middle Ralston Creek	0	1	1
Van Bibber Creek	0		0
Beaver Brook-Clear Creek	1		1
Clear Creek Canyon	1		1

Table C-8. Clear/Bear Creek Final Watershed Ranking

Sixth-level Watershed Name	Wildfire Hazard	Flooding/ Debris Flow	Soil Erodibility	Composite	Water Supply	Overall Ranking
Silver Gulch-Clear Creek	4.6	5.3	5.5	5.5	1	5.5
Mill Creek-Clear Creek	5.0	5.5	4.4	5.2	1	4.9
Soda Creek	5.5	5.0	3.3	4.7	1	4.8
Outlet Chicago Creek	5.4	5.1	3.3	4.7	1	4.7
City of Idaho Springs-Clear Creek	4.5	4.7	4.3	4.6	1	4.6
Evergreen Lake-Bear Creek	4.9	3.2	3.1	3.6	1	3.6
Vance Creek	3.9	2.7	5.5	4.0	0	3.0
North Clear Creek	3.7	3.8	2.2	2.9	1	2.9
Beaver Brook-Clear Creek	3.3	3.8	2.0	2.6	1	2.7
Turkey Creek	5.0	2.2	1.8	2.6	1	2.6
West Fork Clear Creek	2.8	1.6	4.3	2.4	1	2.5
Cub Creek	5.1	3.2	2.2	3.3	0	2.3
Headwaters Bear Creek	2.4	2.5	3.3	2.2	1	2.2
Headwaters Clear Creek	1.5	3.0	3.6	2.2	1	2.2
Middle Ralston Creek	3.0	2.4	2.1	1.9	1	2.0
Fall River	2.1	5.1	2.4	2.8	0	1.9
South Clear Creek	0.5	3.0	3.2	1.5	1	1.6
Clear Creek Canyon	1.7	2.8	2.0	1.5	1	1.5
Upper Ralston Creek	5.3	0.5	1.6	1.8	0	0.9
Mount Vernon Creek-Bear Creek	2.0	1.8	1.4	0.8	1	0.9
Headwaters West Chicago Creek	2.7	2.2	2.3	1.7	0	0.8
Troublesome Creek-Bear Creek	2.4	3.8	0.9	1.7	0	0.8
Bear Creek Lake	1.0	2.6	0.8	0.5	1	0.6
Van Bibber Creek	0.7	3.6	0.5	0.6	0	0.5