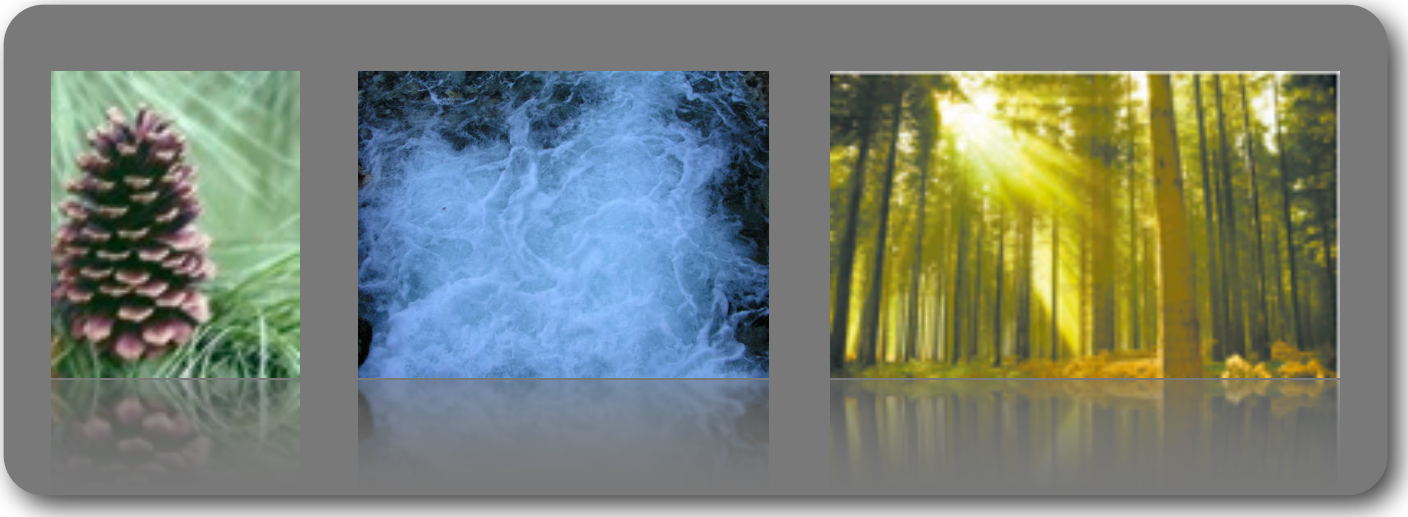
Saint Vrain Wildfire/Watershed Assessment

Prioritization of watershed-based risks to water supplies



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Saint Vrain 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).

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. Three stakeholder meetings have created a diverse group of stakeholders (Appendix A) that have been engaged in the process.

WATERSHED DESCRIPTION

The Saint Vrain 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. It contains five separate streams that come together to form the Saint Vrain before its' confluence with the South Platte River. This watershed assessment is designed to assess hazards from wildfire to water supply. Therefore, the stakeholders agreed that the subwatersheds that are

entirely on the plains to the east be eliminated from this wildfire/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. For this assessment the Saint Vrain Watershed is approximately 500,529 acres in area and is composed of one fourth-level[1] (eight-digit) watershed (HUC 10190005).

The Saint Vrain watershed contains seven fifth-level watersheds and 28 sixth-level watersheds (Figure 1 and Table 1), which are the analysis units for this watershed assessment (Front Range Watershed Protection Data Refinement Work Group 2009). The sixth-level watersheds in the Saint Vrain are 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 large amounts of 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.

[1] The watersheds that were used are part of the existing national network of delineated watersheds. Hydrologic Unit Codes (HUCs) are nested watersheds and are designated numerically by levels (Federal Geographic Data Committee 2004). Sixth-level HUCs or watersheds, use the 11th and 12th digits in the HUC code. Fifth-level HUCs use the ninth and 10th digits in the HUC code.

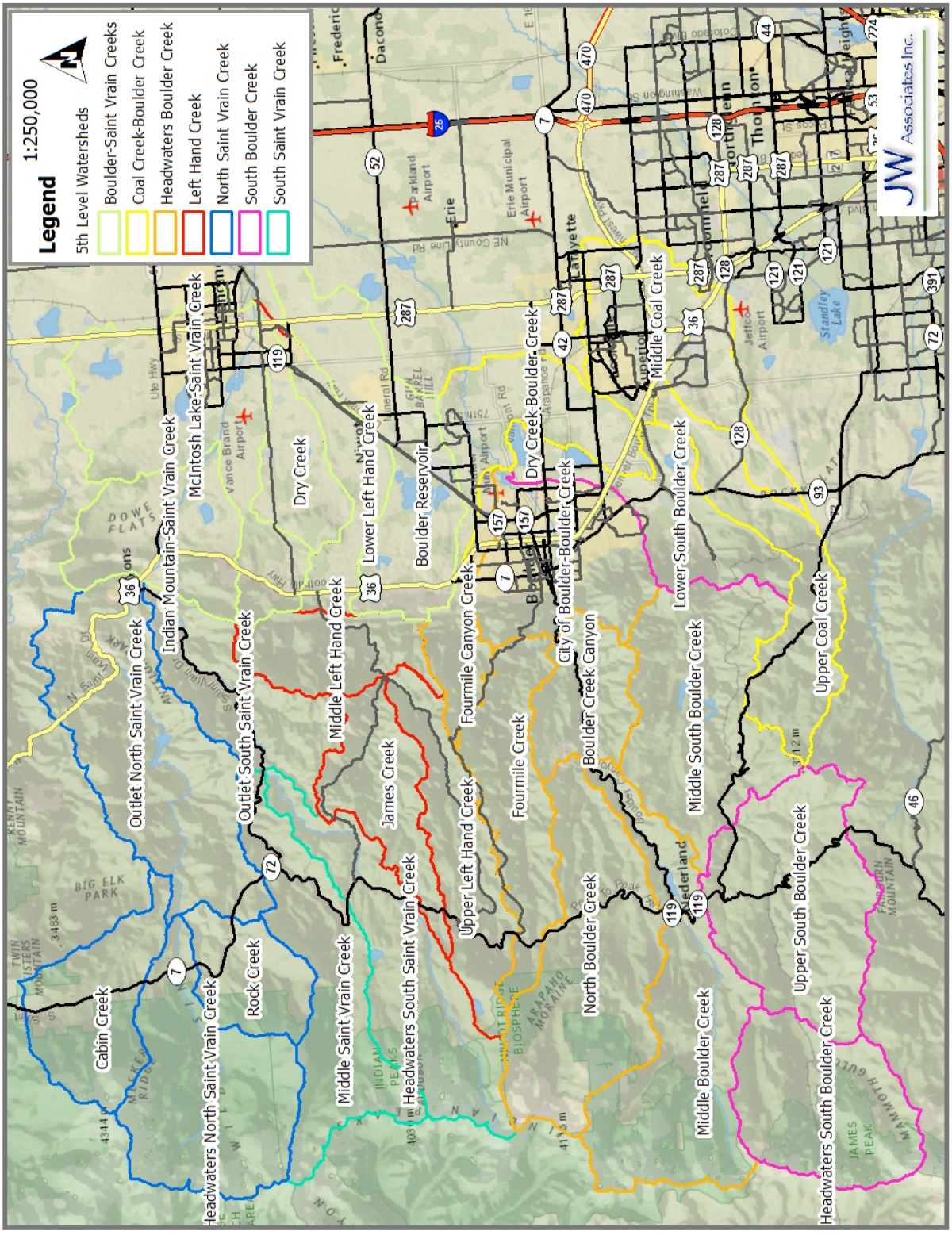


Figure 1. Saint Vrain Watershed Analysis Area[2]

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

Table 1. Fifth-level and Sixth-level Watersheds in Saint Vrain Watershed

Fifth-level Watershed	Sixth-level Watershed	Watershed Area (acres)	Hydrologic Unit Code (HUC)
South Saint Vrain Creek HUC 1019000501	Headwaters South Saint Vrain Creek	21,839	101900050101
	Middle Saint Vrain Creek	20,944	101900050102
	Outlet South Saint Vrain Creek	14,358	101900050103
North Saint Vrain Creek HUC 1019000502	Rock Creek	9,428	101900050201
	Headwaters North Saint Vrain Creek	24,238	101900050202
	Cabin Creek	14,498	101900050203
	Outlet North Saint Vrain Creek	31,351	101900050204
Left Hand Creek HUC 1019000503	James Creek[3]	11,917	101900050301
	Upper Left Hand Creek	14,839	101900050302
	Middle Left Hand Creek	10,290	101900050303
	Lower Left Hand Creek	9,484	101900050304
Headwaters Boulder Creek HUC 1019000504	North Boulder Creek	28,612	101900050401
	Middle Boulder Creek	28,334	101900050402
	Fourmile Creek	15,528	101900050403
	Boulder Creek Canyon	9,783	101900050404
	Fourmile Canyon Creek	6,495	101900050405
	City of Boulder-Boulder Creek	18,556	101900050406
South Boulder Creek HUC 1019000505	Headwaters South Boulder Creek	19,430	101900050501
	Upper South Boulder Creek	26,124	101900050502
	Middle South Boulder Creek	25,637	101900050503
	Lower South Boulder Creek	14,534	101900050504
Coal Creek-Boulder Creek HUC 1019000506	Dry Creek-Boulder Creek	14,059	101900050601
	Upper Coal Creek	16,423	101900050602
	Middle Coal Creek	19,799	101900050603
Boulder Creek-Saint Vrain Creek HUC 1019000507	Indian Mountain-Saint Vrain Creek	14,972	101900050701
	Dry Creek	8,958	101900050702
	McIntosh Lake-Saint Vrain Creek	28,617	101900050703
	Boulder Reservoir	21,482	101900050704
	Total Area	**500,529**	

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 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 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 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 Saint Vrain 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 Saint Vrain 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 procedure 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 Saint Vrain Watershed. Comparisons with other watershed assessments are not valid because this approach prioritizes watersheds by comparing them to the other sixth-level watersheds only 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 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 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 3 + Percentage in Category 4 * 2)

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: Boulder Creek Canyon, Outlet North Saint Vrain, Outlet South Saint Vrain, Rock Creek, and Upper Coal Creek. Eleven watersheds were ranked as Category 4, which the next highest category. Therefore, more than one-half of the watersheds were rated as Category 4 or 5 (see Table C-1 in Appendix C).

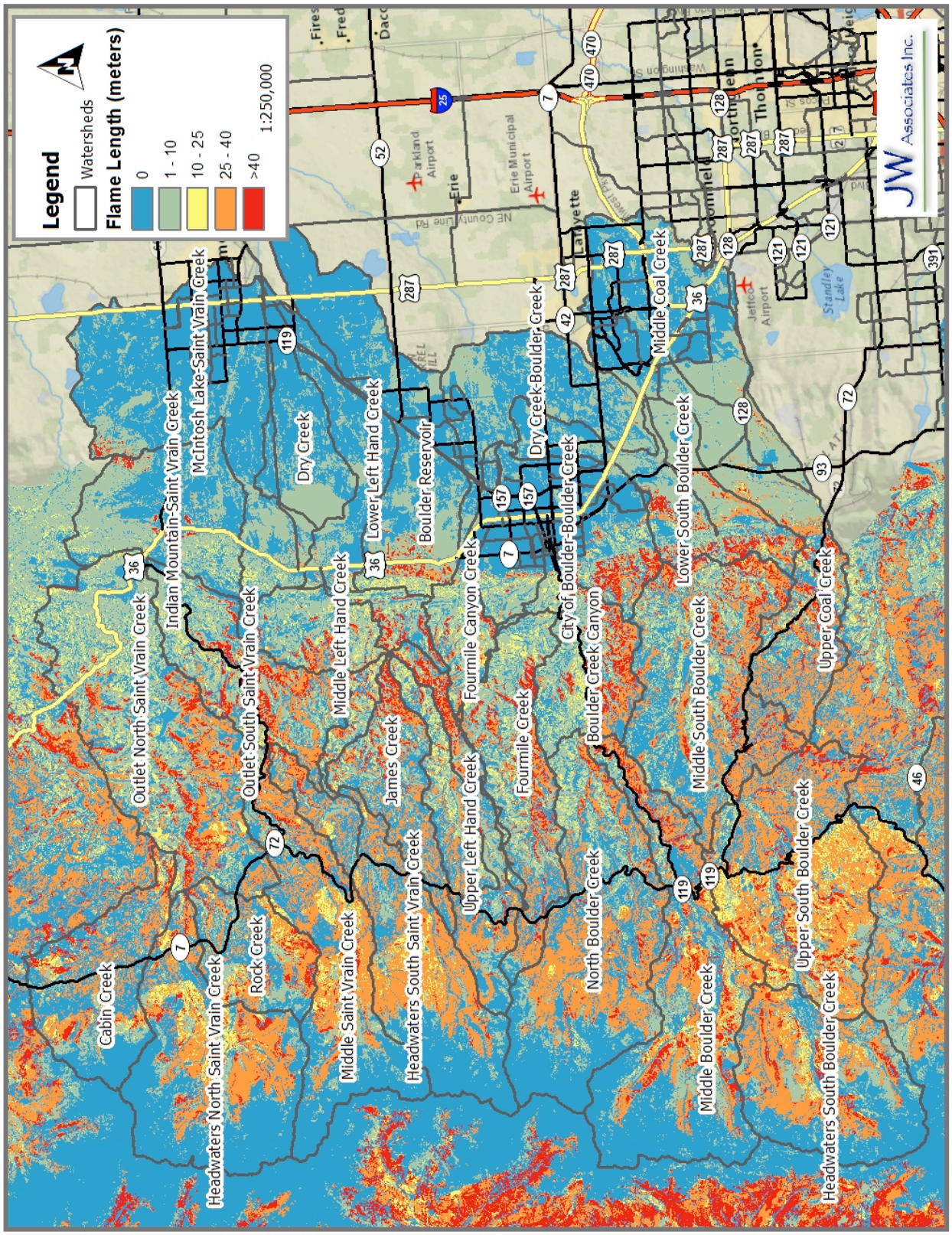


Figure 2. Saint Vrain Watershed Wildfire Hazard Modeling Results

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[3]

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

[3] One chain equals 66 feet

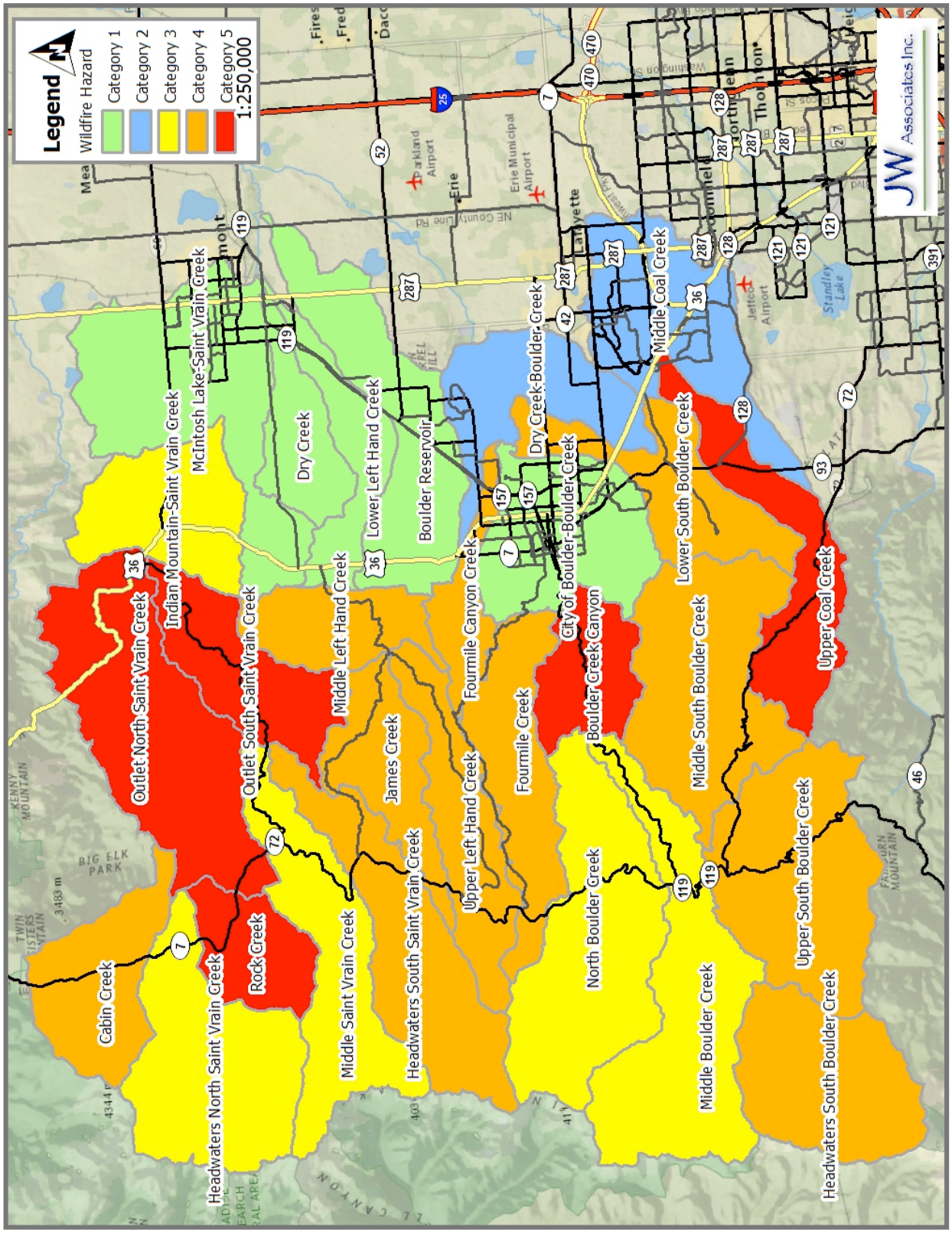


Figure 3. Saint Vrain Watershed Wildfire Hazard Ranking

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 Upper South Boulder Creek watershed.

Figure 4 displays the categorized ruggedness for the Saint Vrain 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; Cabin Creek, Fourmile Creek, Headwaters North Saint Vrain Creek, Headwaters South Saint Vrain Creek, Middle Saint Vrain Creek, Rock Creek, and Upper Left Hand Creek. The upper portions of the watershed are steeper than the lower portions in general.

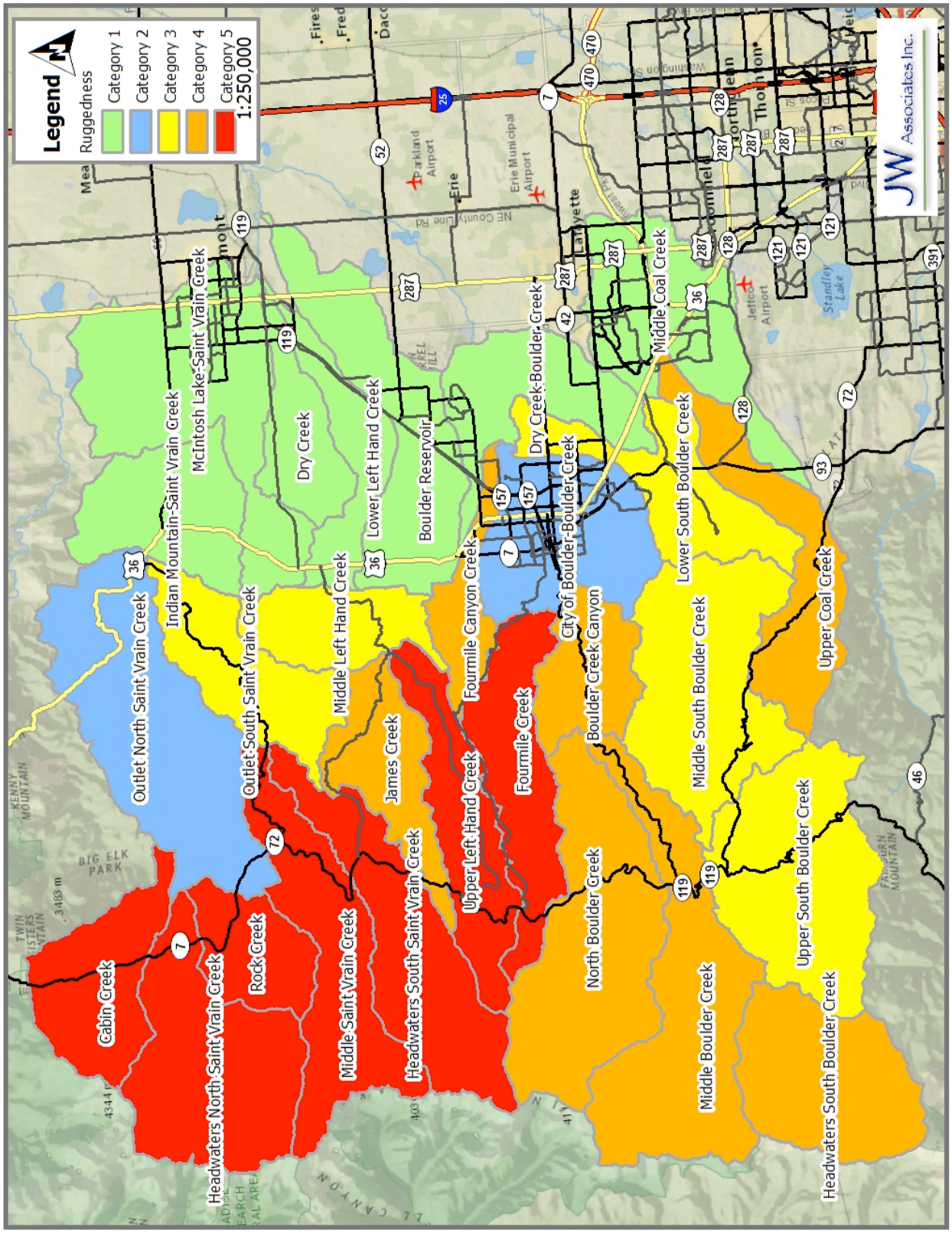


Figure 4. Saint Vrain Watershed Ruggedness Ranking

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 for two separate reasons. One reason for adjusting the road density was the situation where a watershed had a much higher road density than the next highest value, so that watershed was skewing the categorization. In that situation, the watershed was manually given a road density slightly higher than the next highest score.

The other situation where road density was adjusted is 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 Boulder Reservoir, City of Boulder-Boulder Creek, Dry Creek-Boulder Creek, Dry Creek, Indian Mountain-Saint Vrain Creek, MacIntosh Lake-Saint Vrain Creek, Middle Coal Creek, Fourmile Canyon Creek and Lower South Boulder 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 Saint Vrain 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 Boulder Creek Canyon, Fourmile Canyon Creek, Fourmile Creek, Upper Coal Creek and Upper South Boulder Creek watersheds.

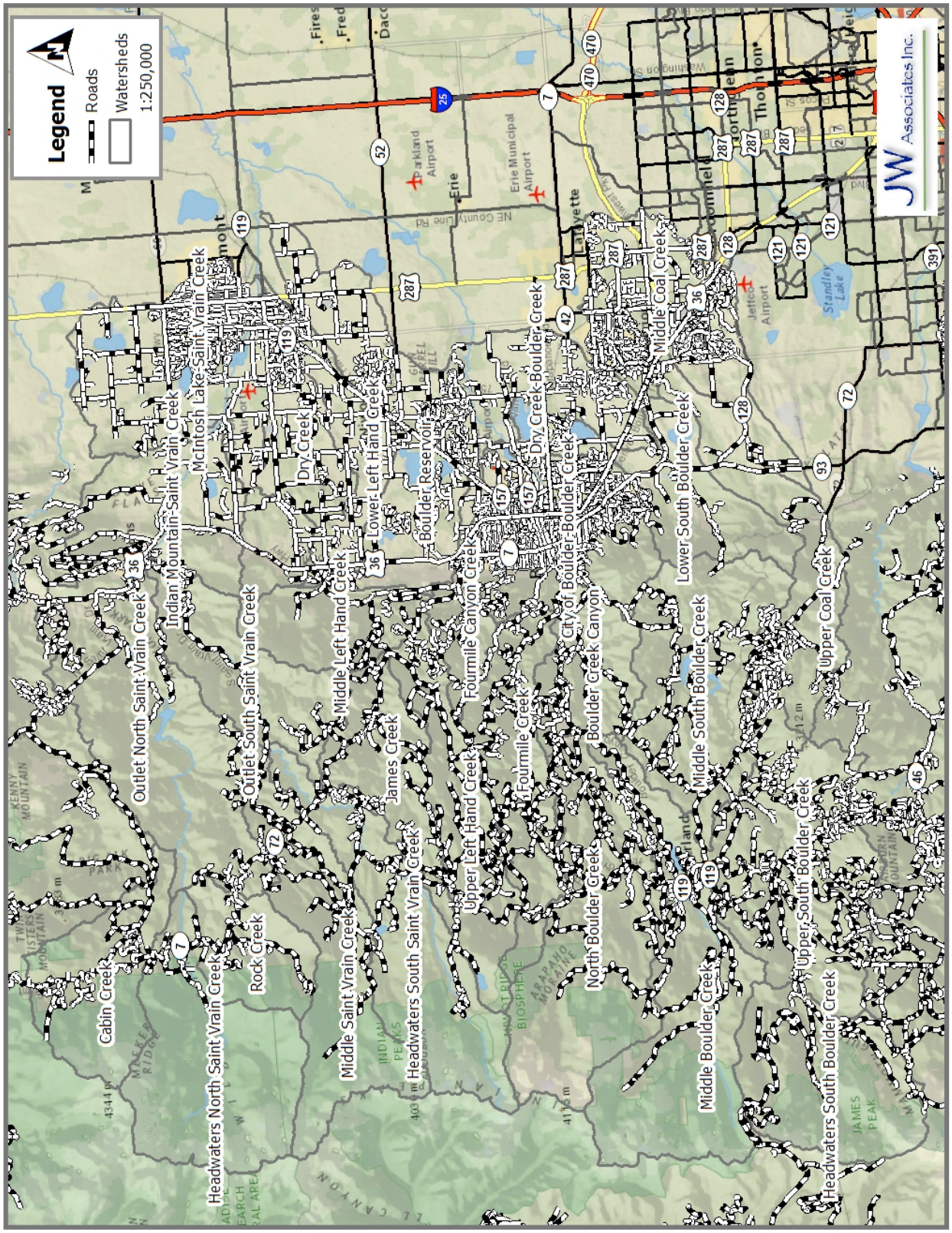


Figure 5. Saint Vrain Watershed Roads Map

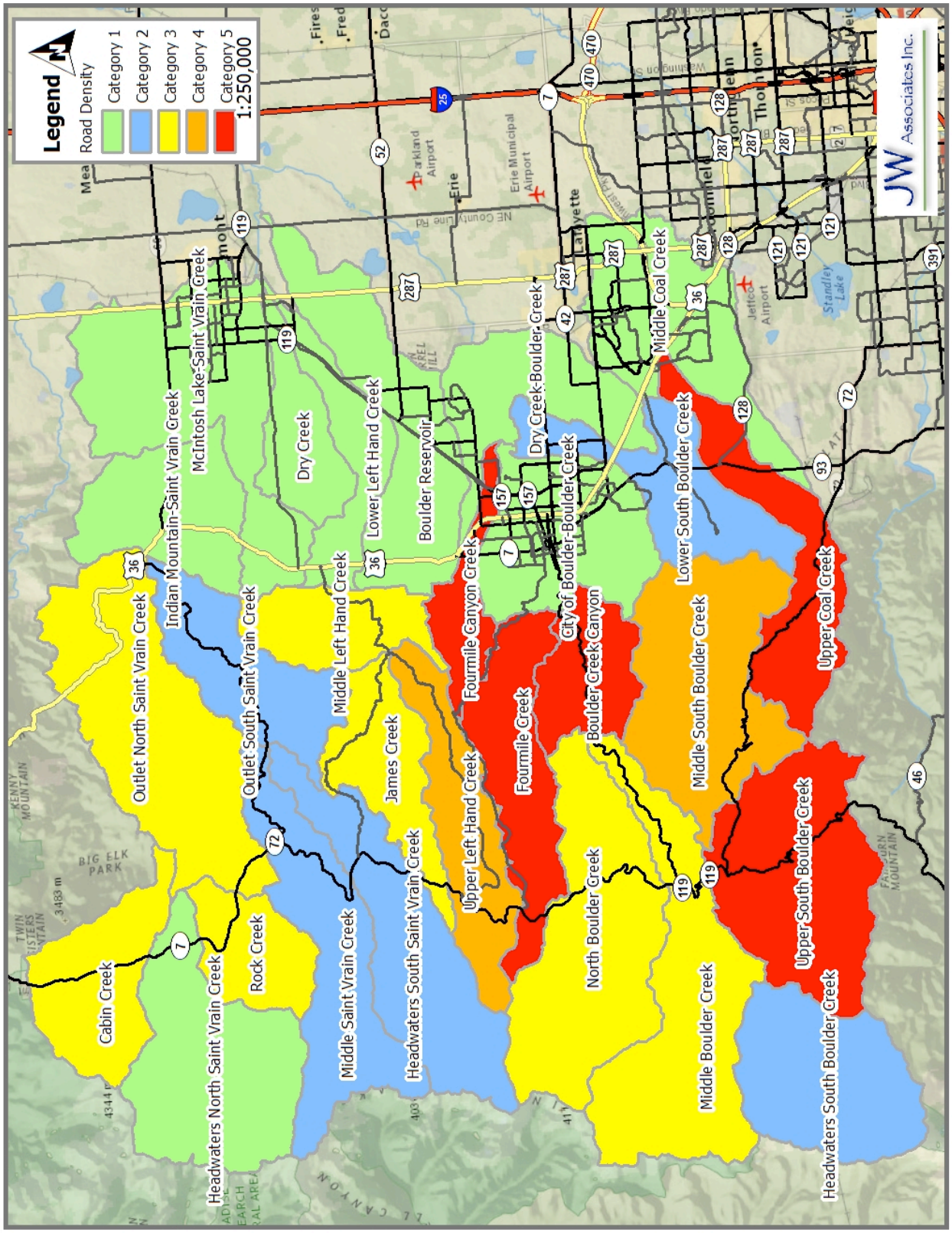


Figure 6. Saint Vrain Watershed Road Density Ranking

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 Saint Vrain 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)

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 Cabin Creek, Fourmile Canyon Creek, Fourmile Creek, Upper Coal Creek and Upper Left Hand Creek.

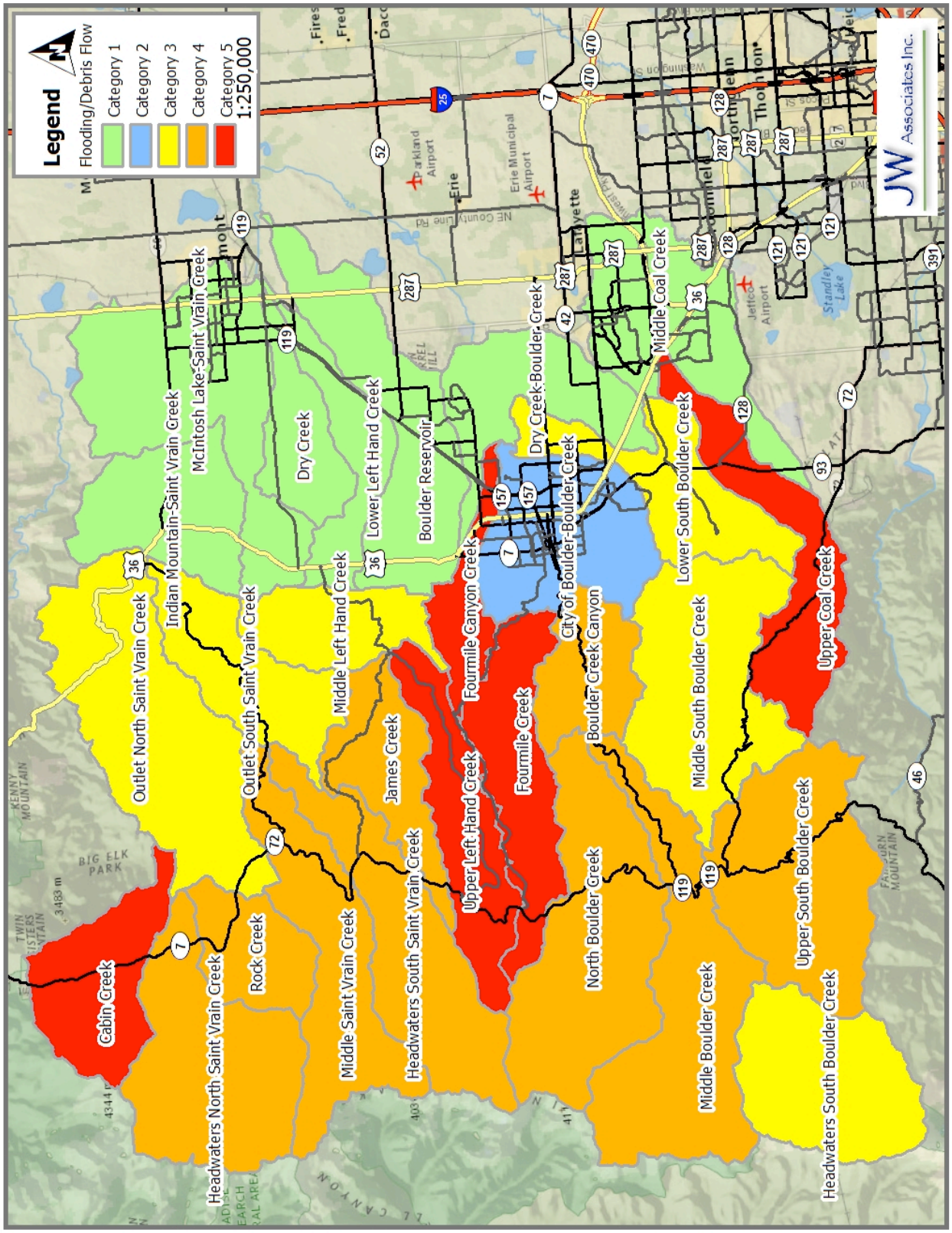


Figure 7. Saint Vrain Watershed Flooding/Debris Flow Hazard Ranking

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 Table C-5 in Appendix C. The highest ranked sixth-level watersheds based on soil erodibility are Boulder Creek Canyon, City of Boulder-Boulder Creek, Fourmile Canyon Creek, Indian Mountain-Saint Vrain Creek, Lower South Boulder Creek, Middle Left Hand Creek, Middle South Boulder Creek, Upper Coal Creek, and Upper Left Hand Creek. The Upper Left Hand Creek, Middle Left Hand Creek, Boulder Creek Canyon, and Indian Mountain-Saint Vrain Creek watersheds were skewing the categorization because of their high soil erodibility values and were manually given a score slightly higher than the next highest score (Table C-5 in Appendix C).

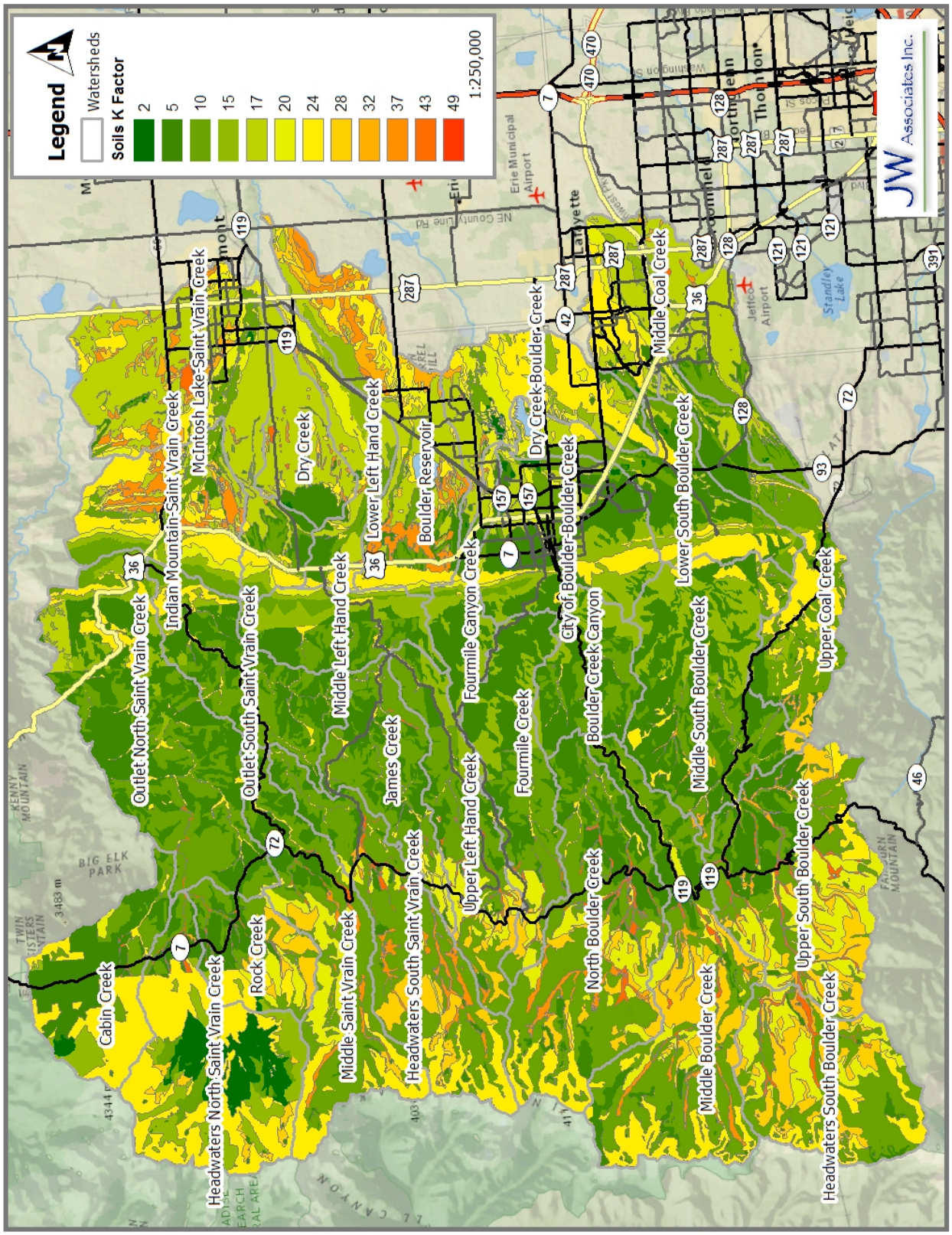


Figure 8. Saint Vrain Watershed Soils K-Factor Map

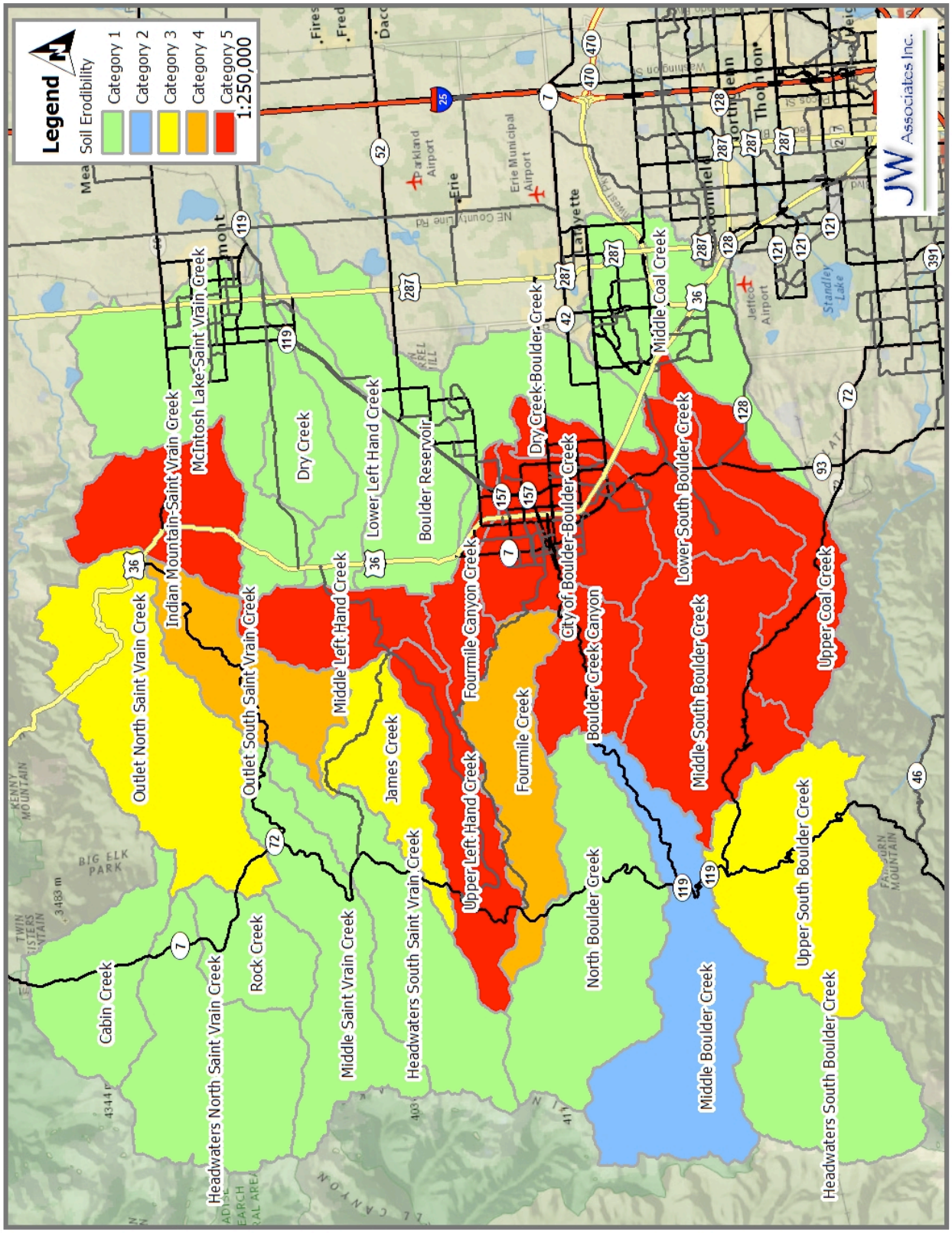


Figure 9. Saint Vrain Watershed Potential Soil Erodibility Hazard Ranking

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 Saint Vrain 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 Boulder Creek Canyon, Fourmile Canyon Creek, Fourmile Creek, Lower South Boulder Creek, Middle Left Hand Creek, MIddle South Boulder Creek, Outlet South Saint Vrain Creek, Upper Coal Creek, and Upper Left Hand Creek. Additionally, there are six 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 nodes.

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.

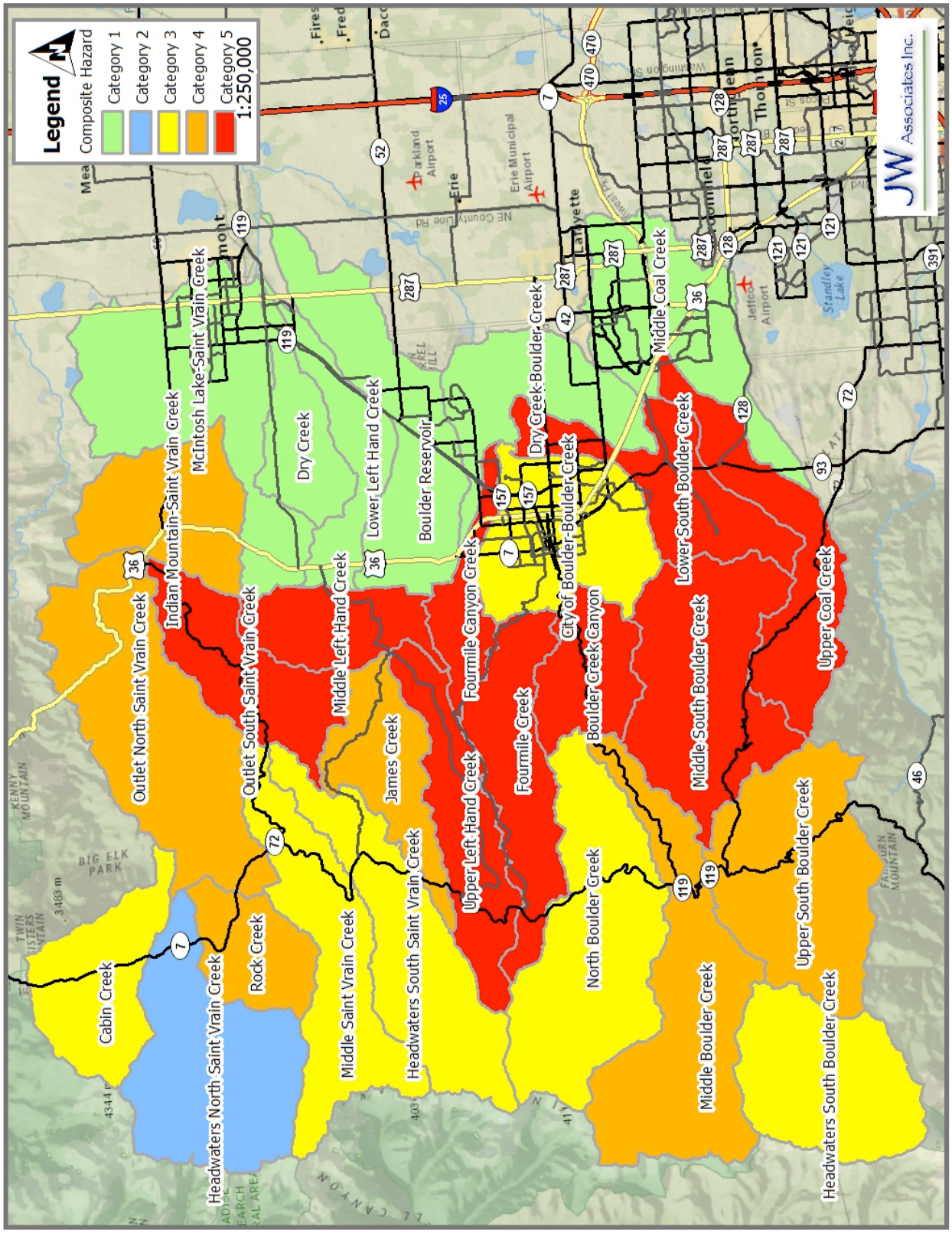


Figure 10. Saint Vrain Watershed Composite Hazard Ranking

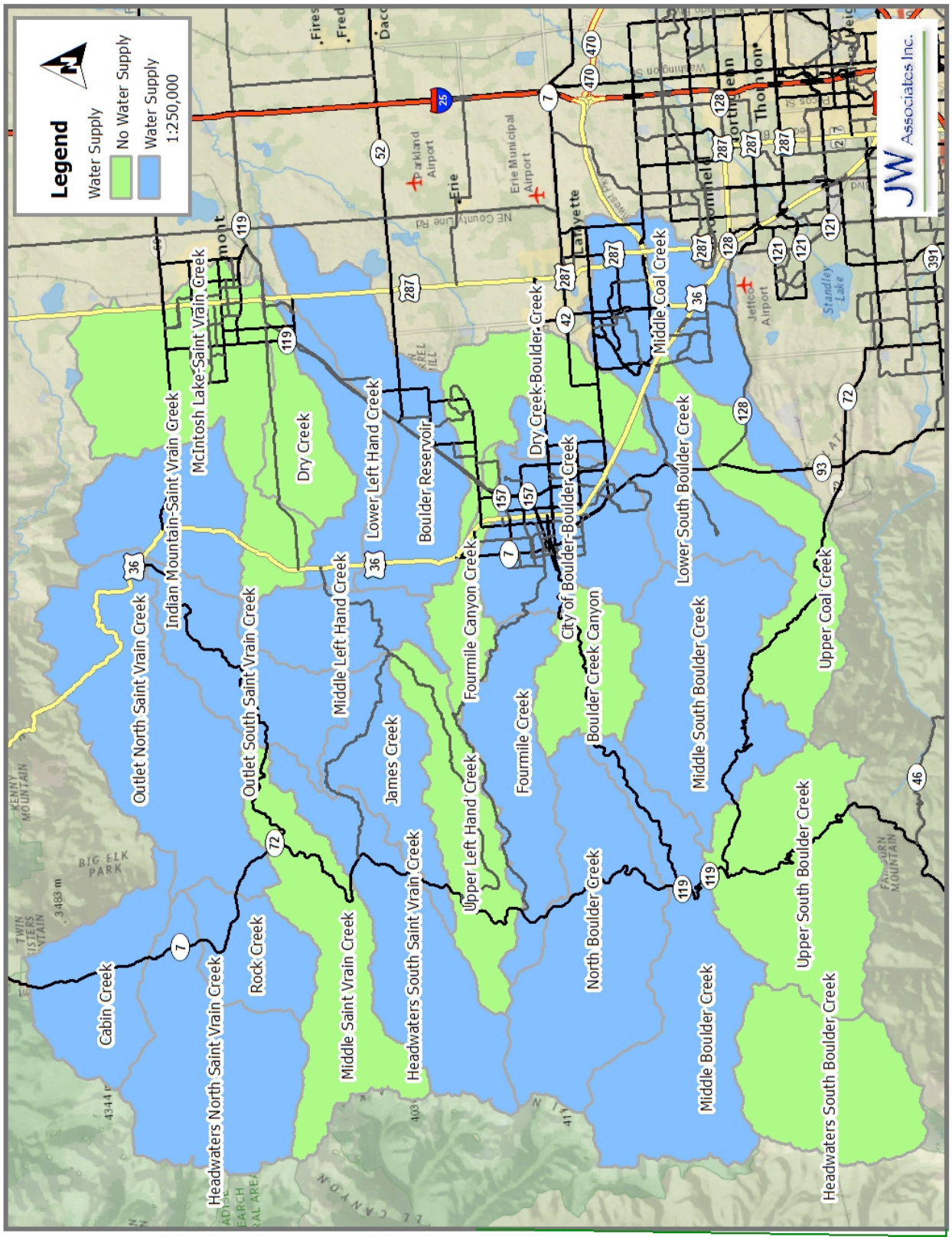


Figure 11. Saint Vrain Watershed Water Supply Map

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 Boulder Creek Canyon, Fourmile Creek, Middle Left Hand Creek, Middle South Boulder Creek, Outlet South Saint Vrain Creek, and Upper Coal Creek.

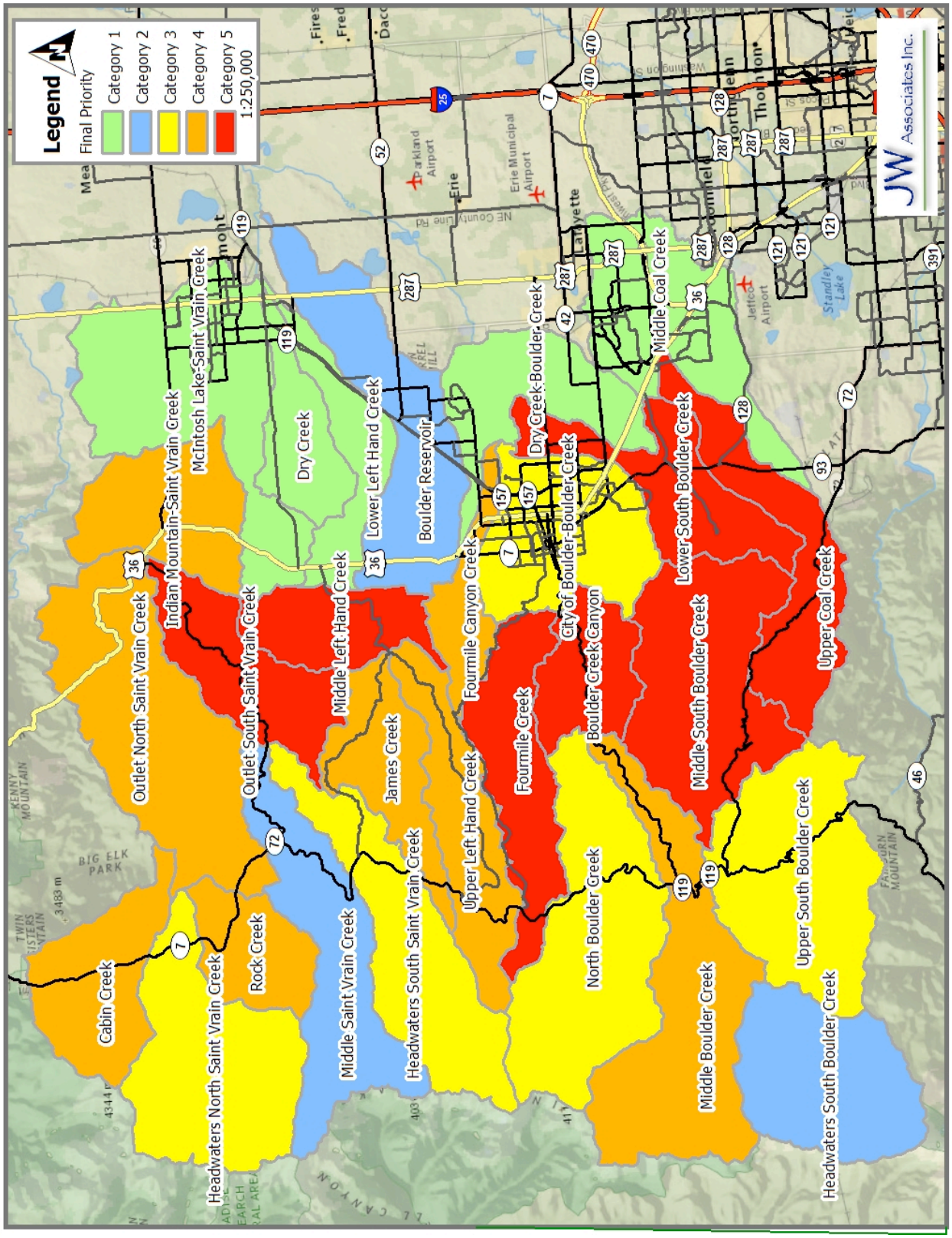


Figure 12. Saint Vrain Watershed Final Priority

Zones of Concern

The Work 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 Saint Vrain 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 Work Group suggested that extending Zones of Concern to There are also 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 Barker Reservoir, James Creek, Left Hand Creek, and North Boulder 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-two ZoC within five miles upstream of diversions and reservoirs were delineated in the Saint Vrain Watershed (Figure 13 and Table 5) totaling more than 174,000 acres. Four of the ZoC were extended to 11 miles upstream increasing the total ZoC area to more than 191,000 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.

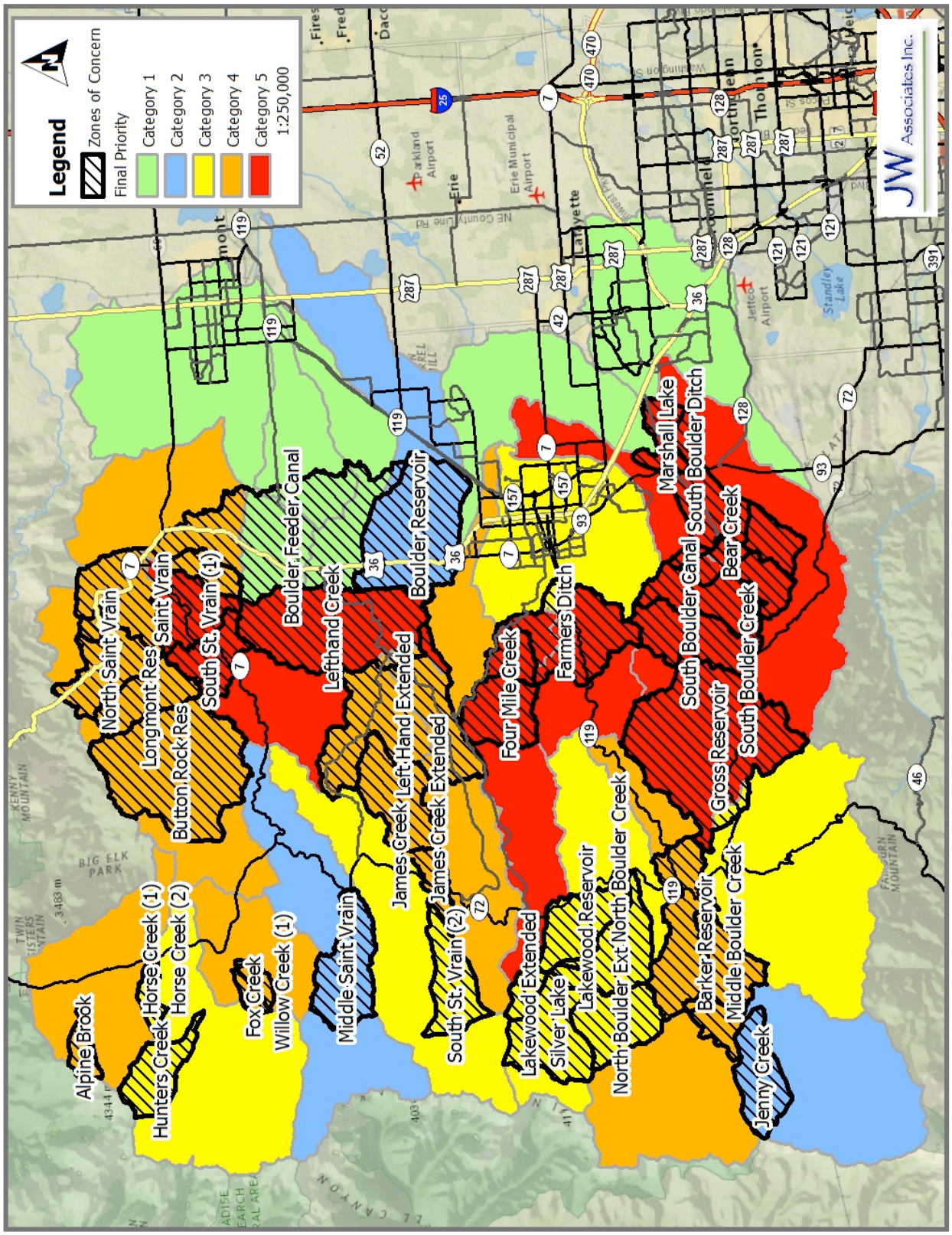


Figure 13. Saint Vrain Watershed Zones of Concern

Table 5. Saint Vrain Watershed Zones of Concern[4]

Name	0-5 Mile ZoC (acres)	5-11 Mile ZoC (acres)	Total ZoC Area (acres)	Water Supply Agency
Alpine Brook	1,171		1,171	Alpine Brook WS
Barker Reservoir	8,922		8,922	City of Boulder
Bear Creek	6,701		6,701	Town of Lafayette
Boulder Feeder Canal	14,411		14,411	City of Boulder
Boulder Reservoir	8,772		8,772	City of Boulder
Button Rock Res	11,574		11,574	City of Longmont
Farmers Ditch	7,791		7,791	City of Boulder
Four Mile Creek	5,083		5,083	Pine Brook Hills WD
Fox Creek	516		516	Meadow Mountain WS
Gross Reservoir	14,682		14,682	Denver Water Department
Horse Creek (1)	872		872	Lane Guest Ranch
Horse Creek (2)	685		685	Meeker Park Lodge
Hunters Creek	2,845		2,845	Wild Basin Ranger Station
James Creek	4,343	1,428	5,771	Town of Jamestown, Left Hand Water Dist.
Jenny Creek	3,436		3,436	Eldora Mtn Resort
Lakewood Reservoir	3,774	1,041	4,815	City of Boulder
Left Hand Creek	10,411	10,771	21,182	Left Hand Water Dist., Town of Niwot, St. Vrain & Left Hand Water Conservancy Dist.
Longmont Reservoir	3,126		3,126	City of Longmont
Marshall Lake	854		854	City of Louisville
Middle Boulder Creek	4,672		4,672	Town of Nederland
Middle Saint Vrain	4,464		4,464	Peaceful Valley
North Boulder Creek	4,277	3,833	8,110	City of Boulder
North Saint Vrain	4,163		4,163	Town of Lyons
Saint Vrain	10,150		10,150	City of Longmont
Silver Lake	5,179		5,179	City of Boulder
South Boulder Canal	7,873		7,873	Denver Water Department
South Boulder Creek	6,930		6,930	Superior Metro District
South Boulder Ditch	6,392		6,392	Town of Erie
South St. Vrain (1)	5,911		5,911	City of Longmont
South St. Vrain (2)	3,365		3,365	Left Hand Water Dist., Town of Niwot
Willow Creek (1)	629		629	Allenspark WC
Willow Creek (2)	577		577	Meadow Mountain WS
Total	**174,551**	**17,073**	**191,624**	

[4] The Zones of Concern are basically watersheds above the water supply location.

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.

Hazard Reduction Strategies

Although there are other strategies that can be pursued, the reduction of wildfire severity is the main 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 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).

There are portions of watersheds that may not be available for 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 by helicopter may be the only option. During follow-up planning efforts the costs of specific project alternatives should be carefully evaluated in light of fire probabilities and the potential costs of no action. An example of administrative inaccessibility would be areas designated by the US Forest Service as wilderness.

There are some prudent measures that can be taken in situations where critical watersheds are economically or administratively inaccessible including;

1. Managing wildland fires in certain places 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.
2. Reduction of wildfire severity in surrounding areas within those watersheds to reduce the potential extent of high severity burn.

3. Pre-permitting sediment control structures downstream from high hazard watersheds. 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. Stakeholders can do much of the permitting work ahead of time, including planning with the appropriate government agencies and conceptual design.

4. Communicating with state and local leaders and other interested groups about the hazards that these watersheds pose. There may be other resources at risk below these watersheds that can be protected, such as; houses in floodplains, important fisheries or riparian areas, and areas of mining tailings that could be a water quality risk if they are transported downstream.

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 - Boulder Ranger District of the Arapaho-Roosevelt National Forest.

2. Colorado State Forest Service - Boulder District

3. Boulder, Gilpin and Jefferson Counties

4. Boulder County Parks and Open Space

5. Home owner associations

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 options.

There is a planning process that is focused on watershed issues called Critical Community Watershed Wildfire Protection Plans (CWP^2). The CWP^2 (see http://www.jw-associates.org/Projects/Work_Group/Work_Group.html) is similar to the Community Wildfire Protection Plan (CWPP) process but expands to include watershed issues. Some existing CWPPs may cover portions of the watersheds/ZoC of interest. It may be more efficient to revise an existing CWPP by incorporating the watershed components from this assessment than to complete the CWP^2 process. Specific treatment areas and priorities identified in existing plans also should be reviewed for their contribution to the watershed protection efforts and incorporated into the expanded plan.

Other efforts, such as source water protection plans, may also gain 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.

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 that those efforts might involve, 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.

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.

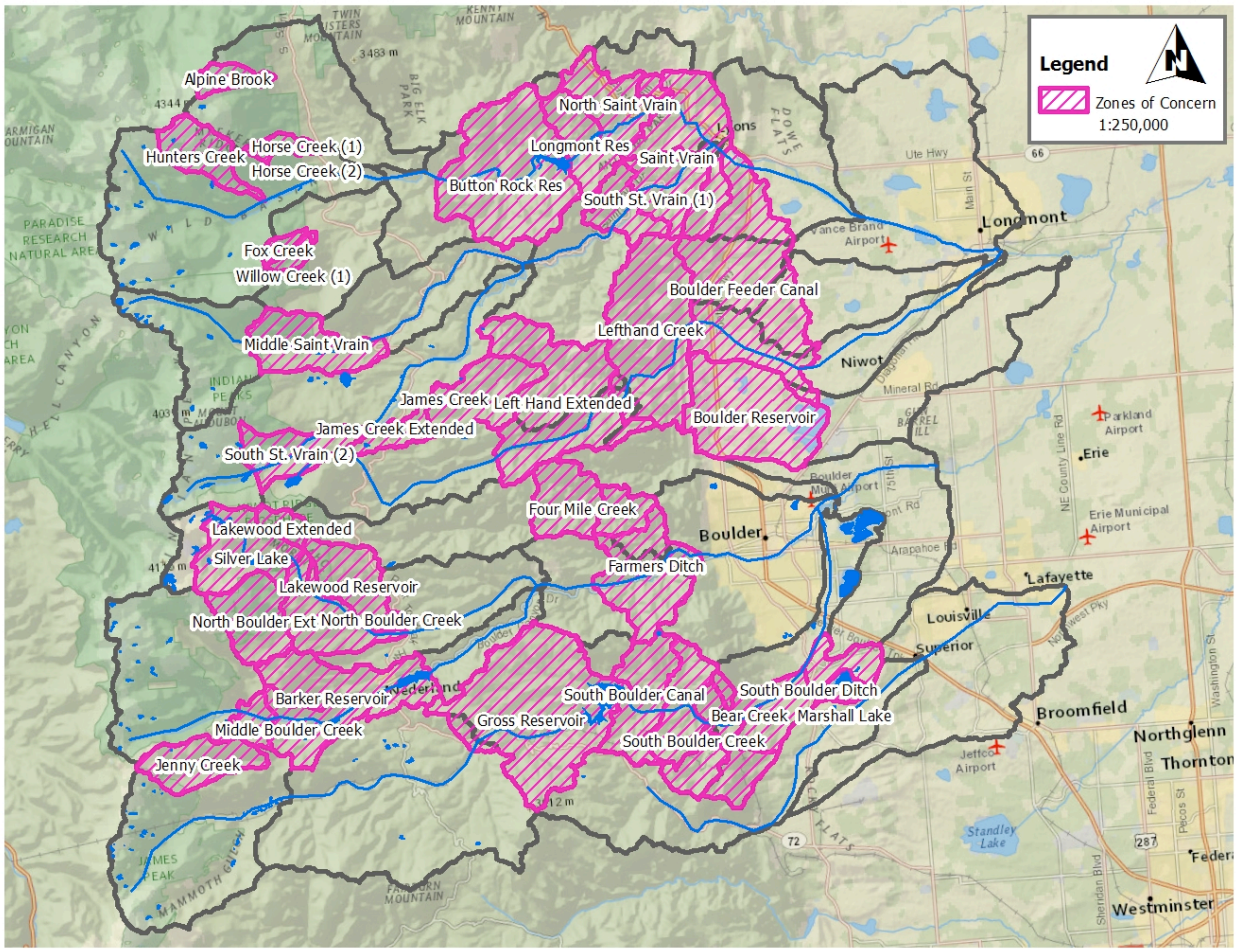


Figure 14. Saint Vrain ZoC Base Map

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.

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.

Colorado is attempting to develop rules for treatments within federal Roadless Areas. The Colorado Roadless Areas are currently under review by the Secretary of Agriculture, but are operating under the proposed Colorado Roadless Rule. This situation has resulted in Roadless Areas being divided into 2001 Roadless Rule (Federal) and Colorado Roadless Areas. Due to current legal actions, 2001 Roadless Rule areas are basically off limits to forest management. However, they should not be viewed as off limits to long-term watershed protection efforts.

The Colorado Roadless Areas have been reviewed and adjusted for actual conditions and therefore are likely more precise than the 2001 Roadless Rule areas. As currently proposed, 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 USFS Regional Forester.

On April 15, 2011 changes to the Colorado Roadless Areas were published in the Federal Register (36 CFR Part 294, Vol. 76, No. 73). The major change was the addition of Upper Tier designations for specific Roadless Areas that further restricted activities allowed. The Upper Tier designation would not allow tree cutting and temporary road building for watershed protection. These Upper Tier (FEIS Alternative 2) areas are displayed on the maps for each ZoC below.

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 Saint Vrain 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 Saint Vrain 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 Saint Vrain 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 normal 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. This much needed 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 Saint Vrain 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-Infested 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 infested 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 increases over time during the grey stage. In Canada, mechanized equipment and access are available for much of its initial fire attack and suppression work. Understand that in many parts of Colorado, we may not have this option.

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. Anticipate hot surface fires with high resistance to control 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.

Summary

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.

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 prior to wildfire incidents.

Rocky Mountain National Park ZoC

This section addresses the northwestern portion of the assessment area that is mostly within Rocky Mountain National Park. The Alpine Brook, Hunters Creek, Horse Creek (1 and 2), Fox Creek and Willow Creek (1 and 2) ZoC are discussed in this section because they are adjacent or overlapping (Figure 15). Note that the ZoC are shown here in pink with crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

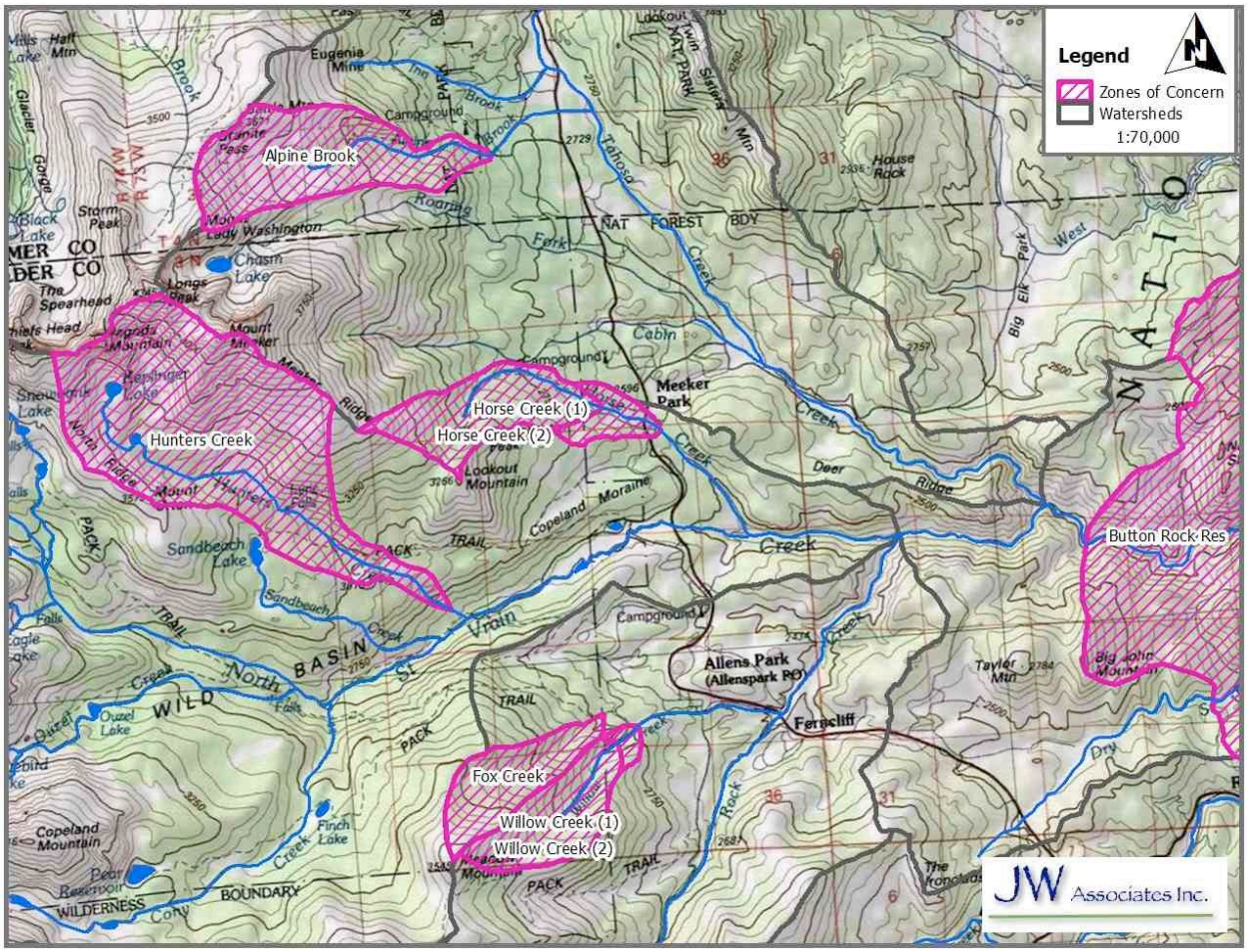


Figure 15. Rocky Mountain National Park ZoC Location

Rocky Mountain National Park Ownership

Alpine Brook, Horse Creek 1, Hunters Creek and Fox Creek ZoC are entirely within Rocky Mountain National Park (Figure 16). The Horse Creek 2 ZoC is within Rocky Mountain National Park except for a small area that is National Forest System (NFS) land on the eastern boundary. The Willow Creek (1 and 2) ZoC are on NFS lands.

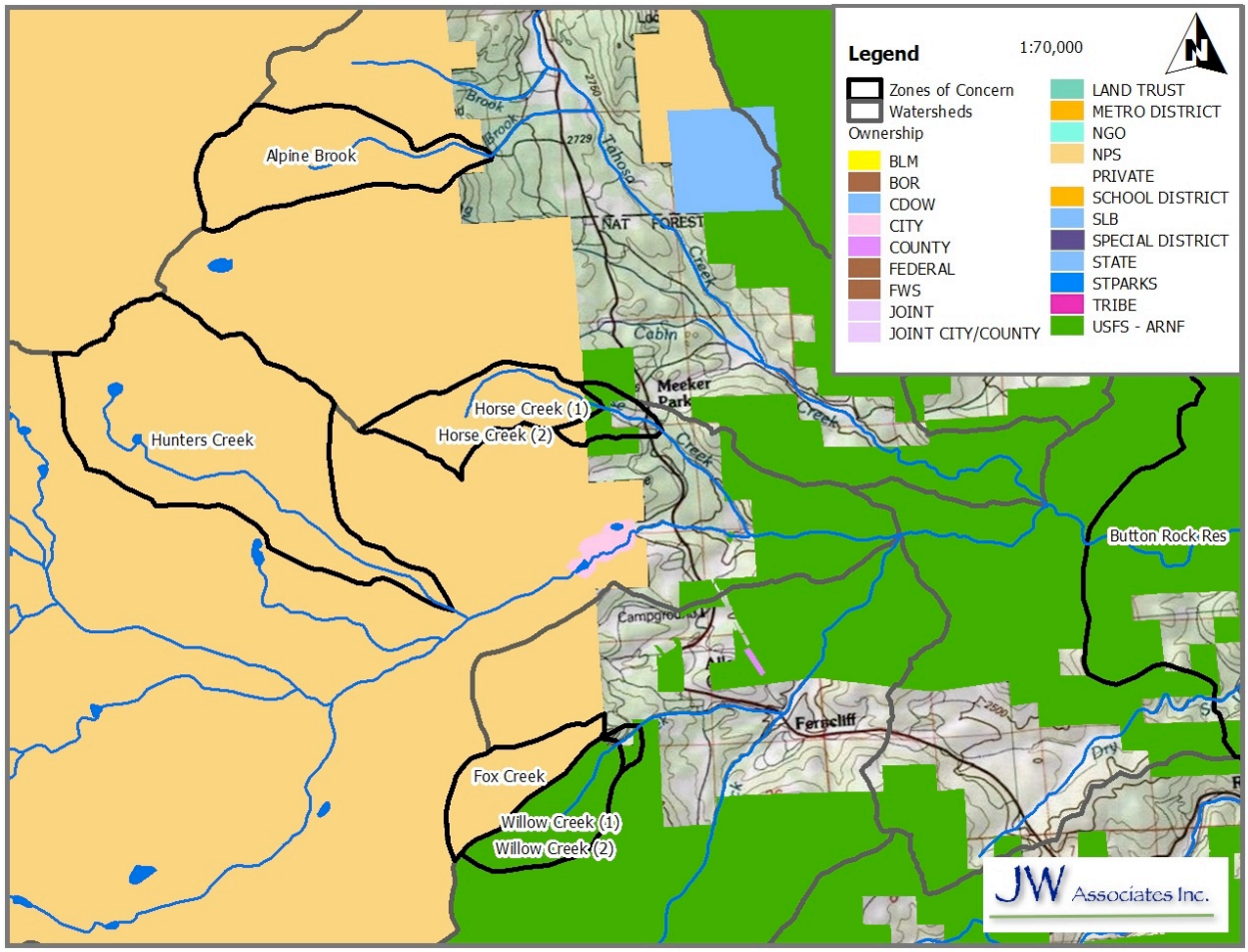


Figure 16. Rocky Mountain National Park ZoC Ownership

Rocky Mountain National Park Watershed Priority

The Cabin Creek watershed is ranked as Orange (Category 4) overall and Wildfire Hazard. It is also ranked as Red (Category 5 - highest) for Flooding/Debris Flow Hazard (Figure 17). The Headwaters North Saint Vrain Creek watershed is ranked as Yellow (Category 3) overall. It is also ranked as Orange (Category 4) for Wildfire Hazard and Flooding/Debris Flow Hazard. The Rock Creek watershed is ranked as Orange (Category 4) overall, and for Flooding/Debris Flow Hazard and Composite Hazard. It is also ranked as Red (Category 5 - highest) for Wildfire Hazard (Figure 17).

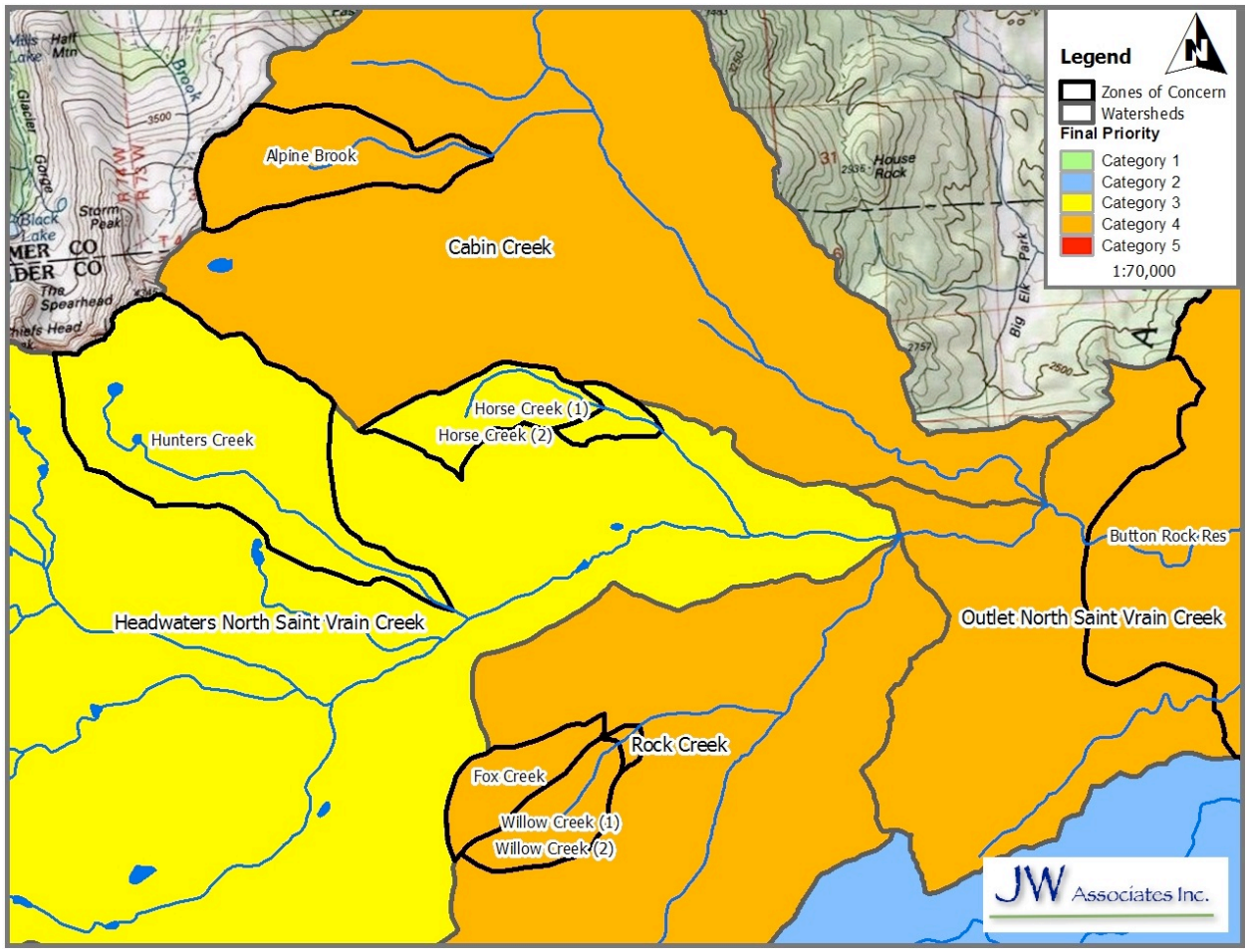


Figure 17. Rocky Mountain National Park ZoC Watershed Priority

Rocky Mountain National Park Slopes

The Alpine Brook ZoC has mostly shallow slopes with some steep slopes in the northern and western portions (Figure 18). The Horse Creek (1 and 2) ZoC both have shallow slopes in the eastern portions of the ZoC with steep slopes dominating the western portion. The Hunters Creek ZoC has mostly steep slopes with a band of shallower slopes south of Hunters Creek. The Fox Creek ZoC is almost entirely shallow slopes (Figure 18). The Willow Creek (1 and 2) ZoC have a few areas of shallow slopes but has large areas of steep slopes.

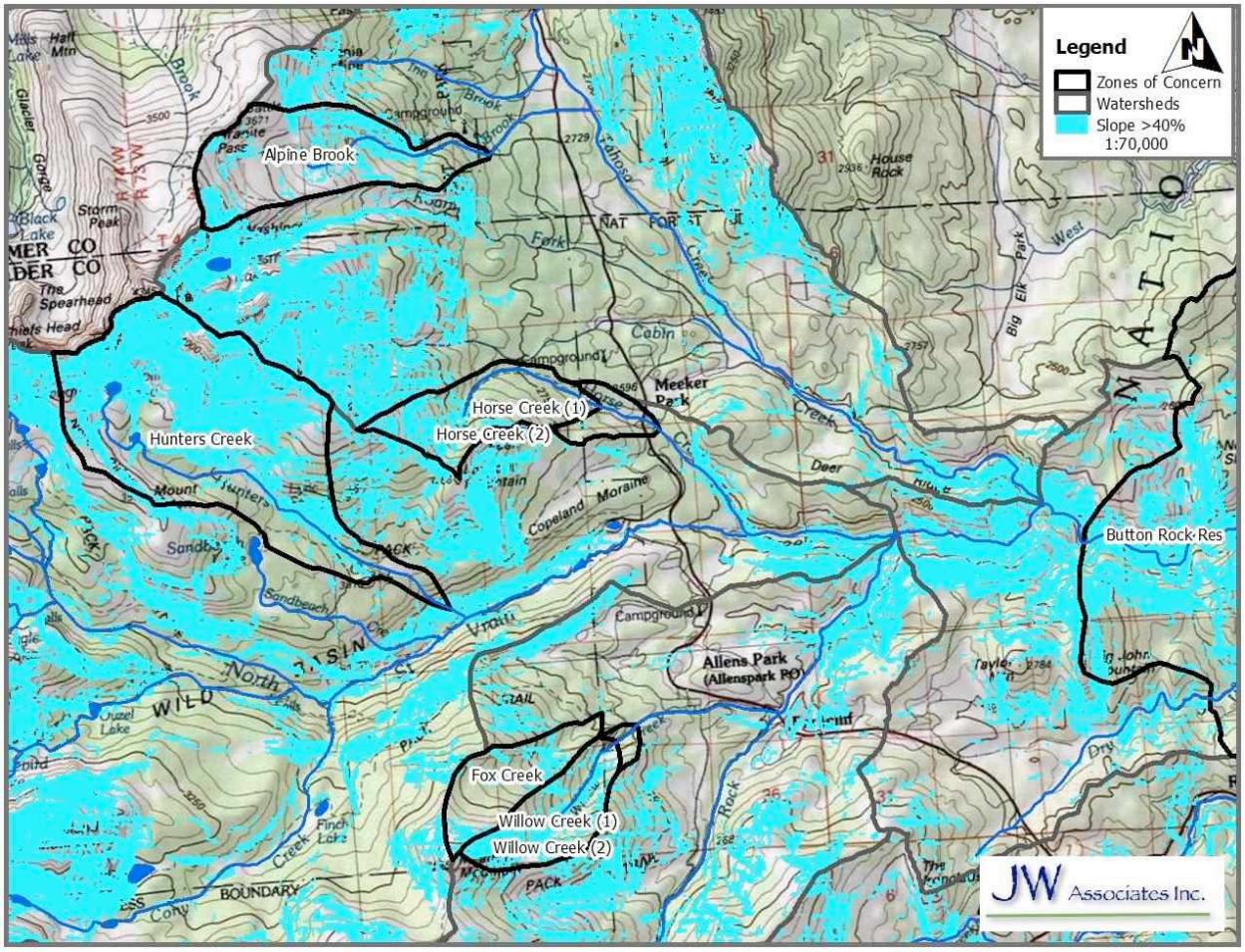


Figure 18. Rocky Mountain National Park ZoC Slopes

Rocky Mountain National Park Special Areas (Wilderness/Roadless)

The majority of these ZoC are all or mostly within Rocky Mountain National Park, shown in orange cross hatching on Figure 19. The Willow Creek (1 and 2) ZoC are nearly all within the Indian Peaks Wilderness Area.

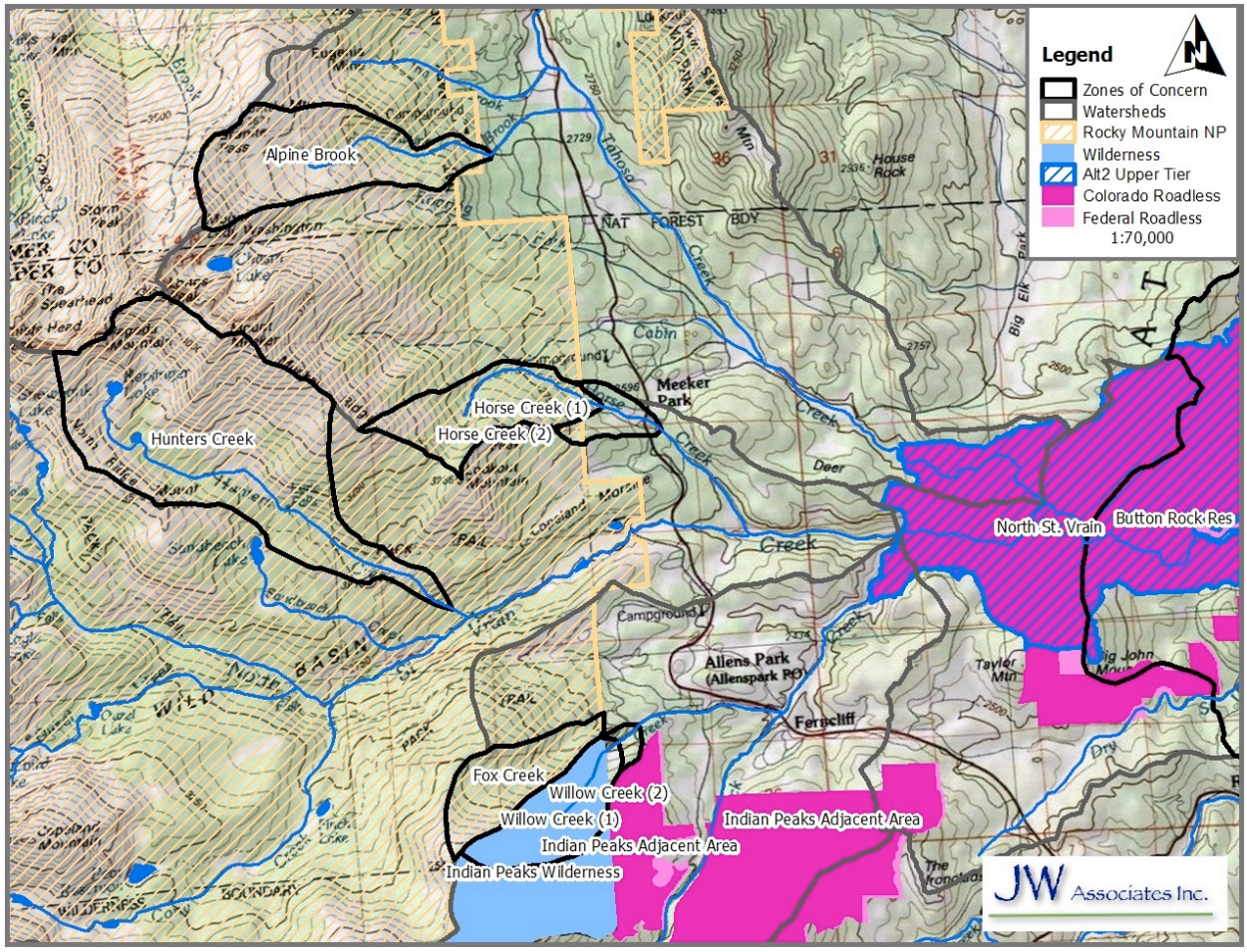


Figure 19. Rocky Mountain National Park ZoC Special Areas

Rocky Mountain National Park Vegetation

These ZoC all transition from a mixture of lodgepole pine and aspen through spruce-fir and to alpine areas (Figure 20). The Horse Creek (1 and 2) ZoC have the largest areas of aspen and the smallest areas of spruce-fir and alpine. The Fox Creek and Willow Creek (1 and 2) ZoC have equal amounts of aspen, lodgepole pine and spruce-fir, with small areas of alpine. The Alpine Brook ZoC has more than half of the ZoC in spruce-fir and alpine. The Hunters Creek ZoC is mostly alpine with small areas of lodgepole pine and aspen.

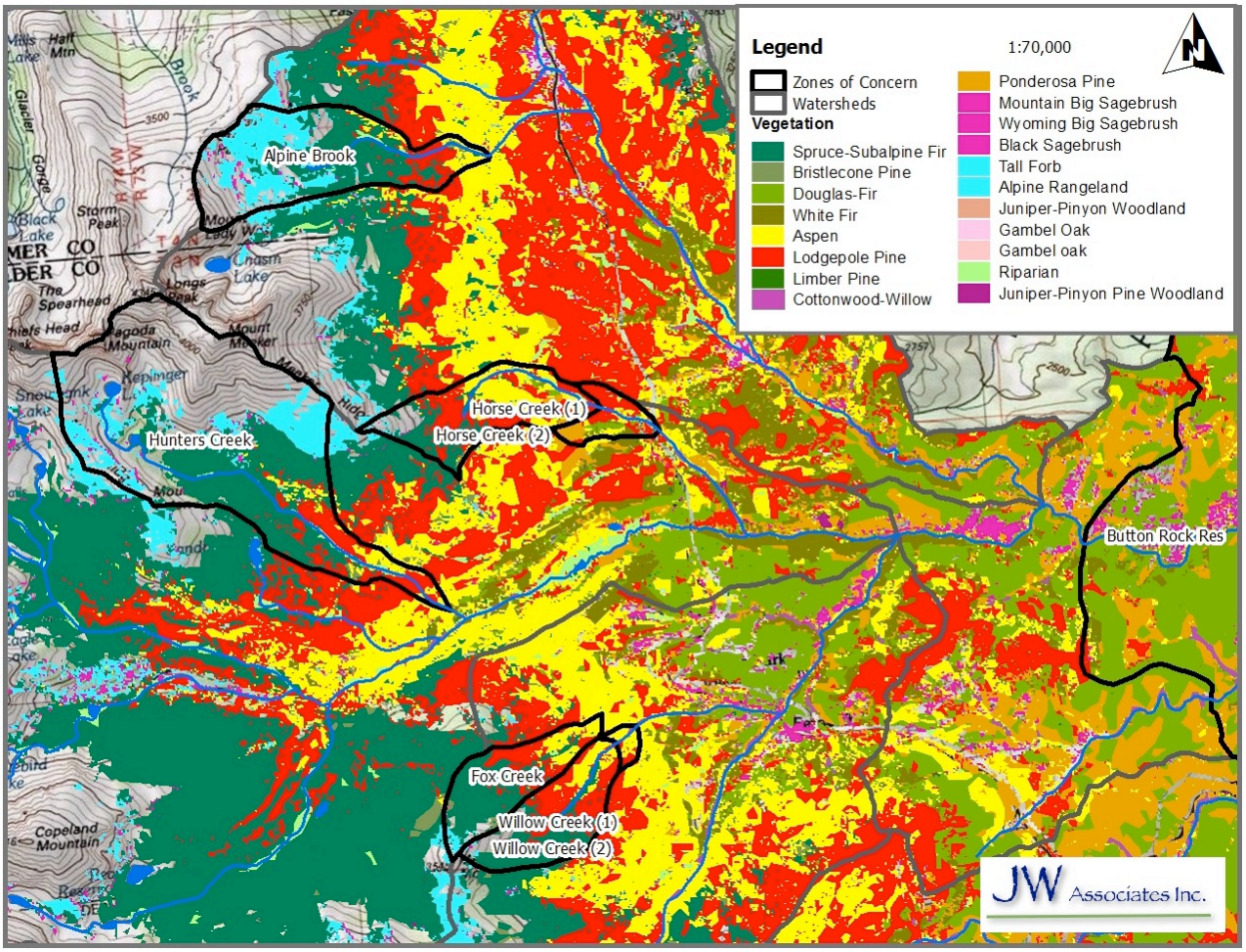


Figure 20. Rocky Mountain National Park ZoC Vegetation

Rocky Mountain National Park Past Fires

There are no recent past fires that have been mapped within these ZoC (figure 21). The Ouzel Fire burned in 1978 between the Hunters Creek and Fox Creek ZoC. It appears to have burned in lodgepole pine and spruce fir forest at relatively high intensity.

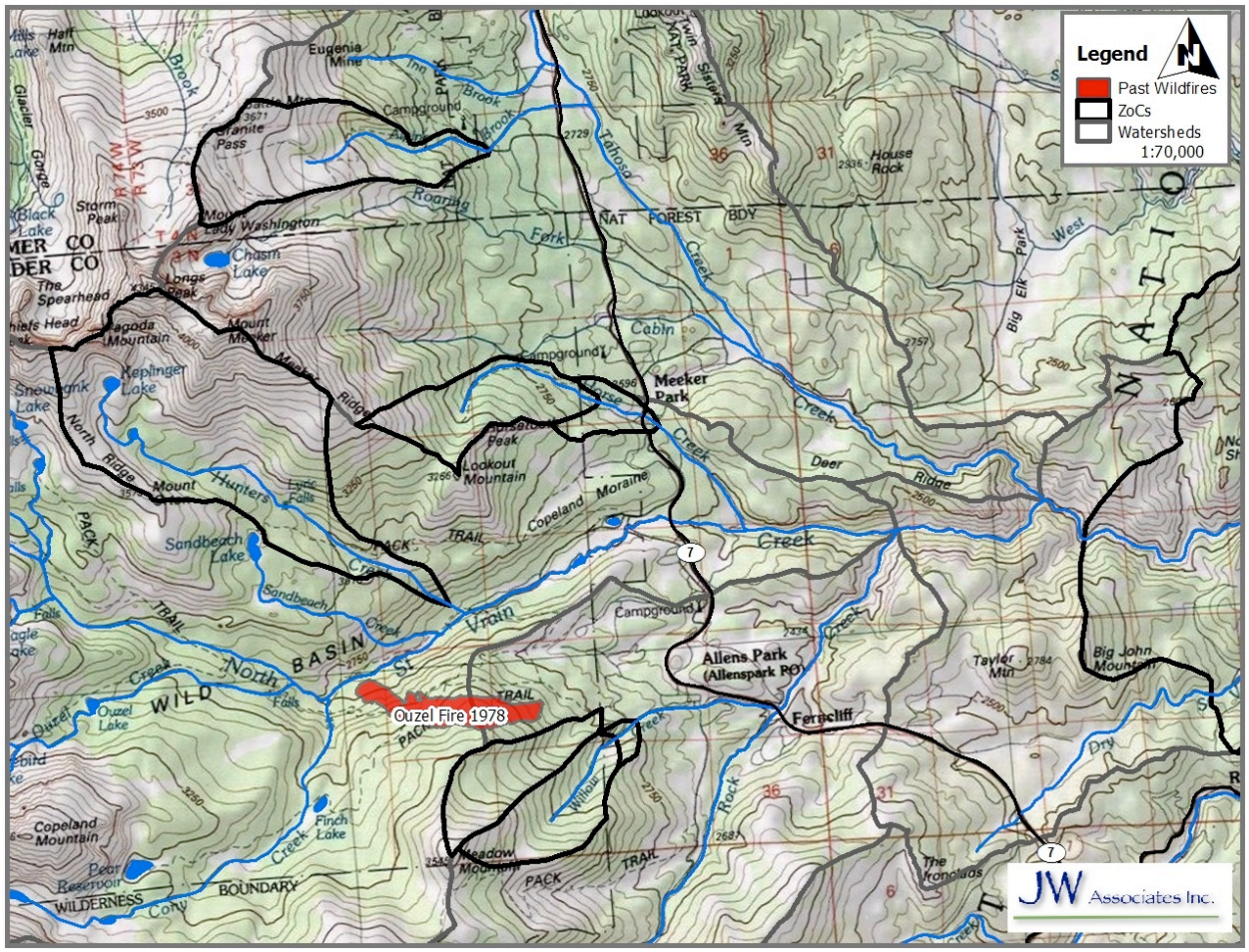


Figure 21. Rocky Mountain National Park ZoC Past Fires

Rocky Mountain National Park Access

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

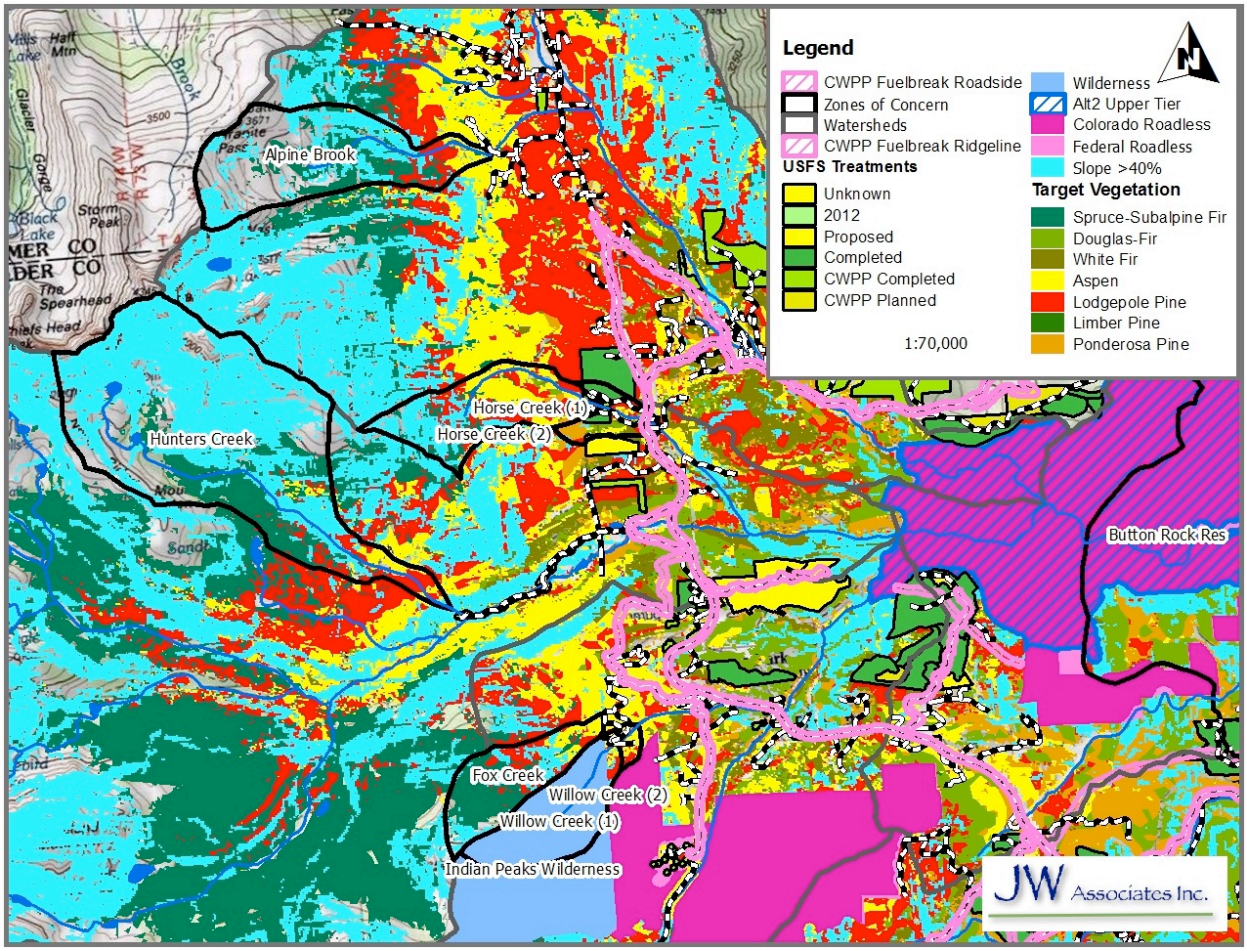


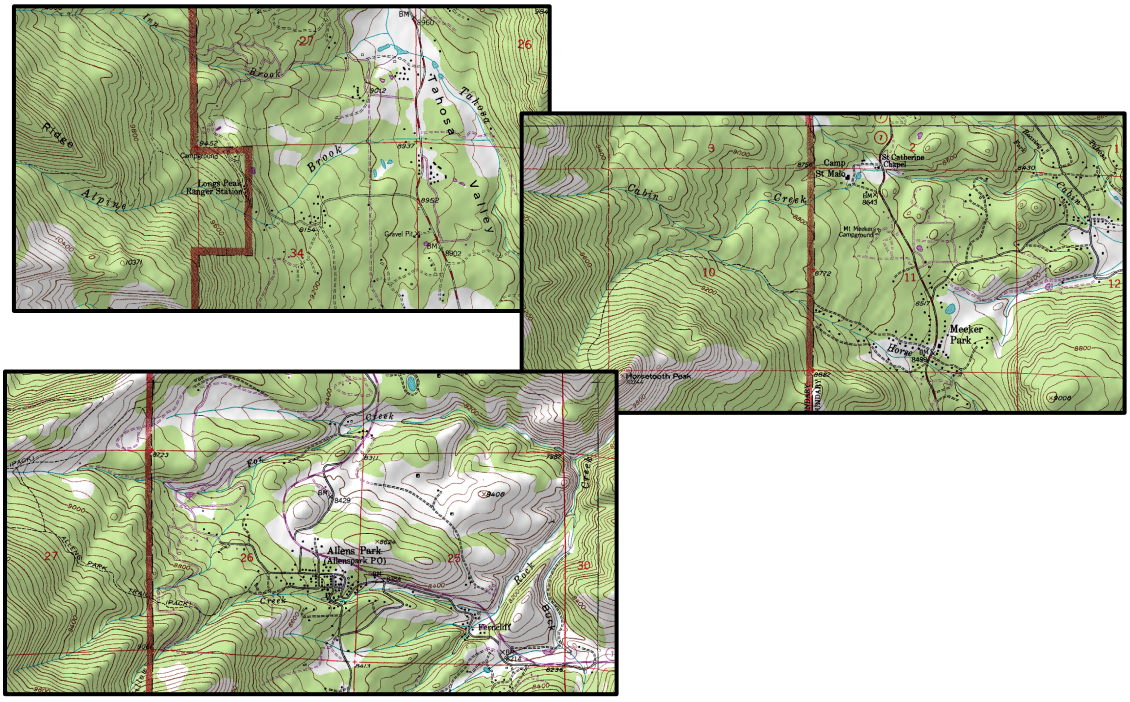
Figure 22. Rocky Mountain National Park ZoC Opportunities

Rocky Mountain National Park Opportunities

Few management opportunities exist within the Rocky Mountain National Park ZoC because of ownership, land classification, and legal and administrative restrictions on mechanical treatments. The greatest opportunities for management are located at the eastern ends of some of the watersheds on non-federal lands. Treatments should be considered immediately outside the ZoC to help prevent wildfires from moving upslope into the watersheds. Examination of the topographic maps for these areas shows that these areas are well-roaded and have slopes that are easily operated on.

Many treatments are proposed or planned for these areas as shown on Figure 22 and in the Boulder County CWPP. Review local CWPPs and work closely with local Fire Protection Districts to implement their plans. Supporting development of comprehensive, community-based defensible space installation can help prevent structure fires from moving into the forest and upslope into the watersheds.

Develop an information & education plan in conjunction with the National Park Service and US Forest Service to inform visitors about the importance of the area's watersheds and the danger of wildfire to water quality. Work with the National Park 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.



Lands low in the ZoC and to their east present opportunities for management to help keep fires from moving upslope into the watersheds.

Middle Saint Vrain ZoC

This section discusses the Middle Saint Vrain and South Saint Vrain 2 ZoC, and the James Creek Extended ZoC because they are adjacent or overlapping (Figure 23). The lower James Creek ZoC is part of the Left Hand Creek ZoC discussion below. The South Saint Vrain 1 ZoC is part of the Button Rock ZoC discussion below. Note that the ZoC are shown here in pink with crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

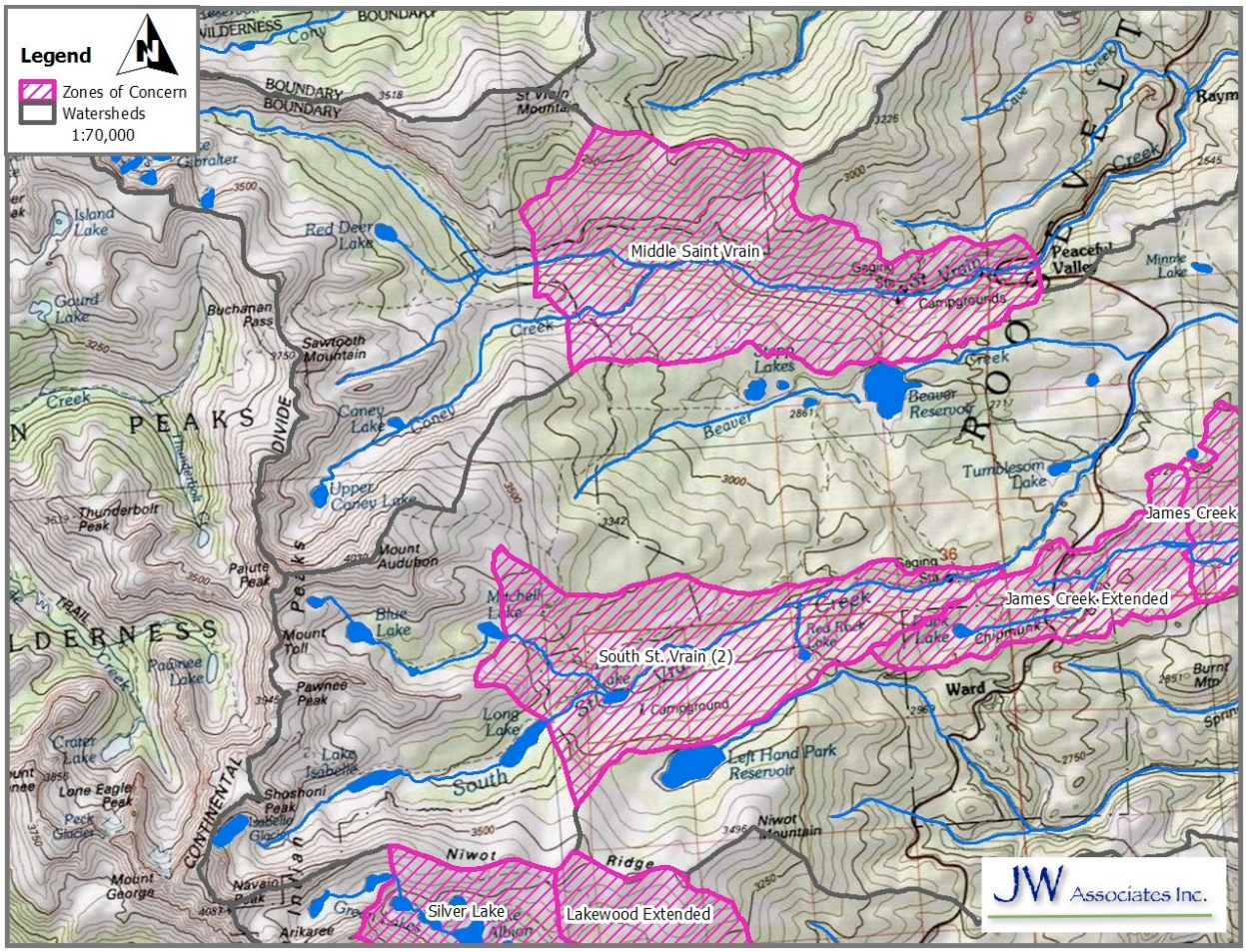


Figure 23. Middle Saint Vrain ZoC Location

Middle Saint Vrain Ownership

The Middle and South Saint Vrain ZoC are nearly all on NFS lands (Figure 24). The lower portion of the Middle Saint Vrain ZoC has some private lands. The lowest portions of the South Saint Vrain ZoC are a mix of private, Boulder County Open Space and Colorado State Land Board lands. The James Creek Extended ZoC is a mixture of private, Boulder County Open Space, State of Colorado and NFS lands (Figure 24).

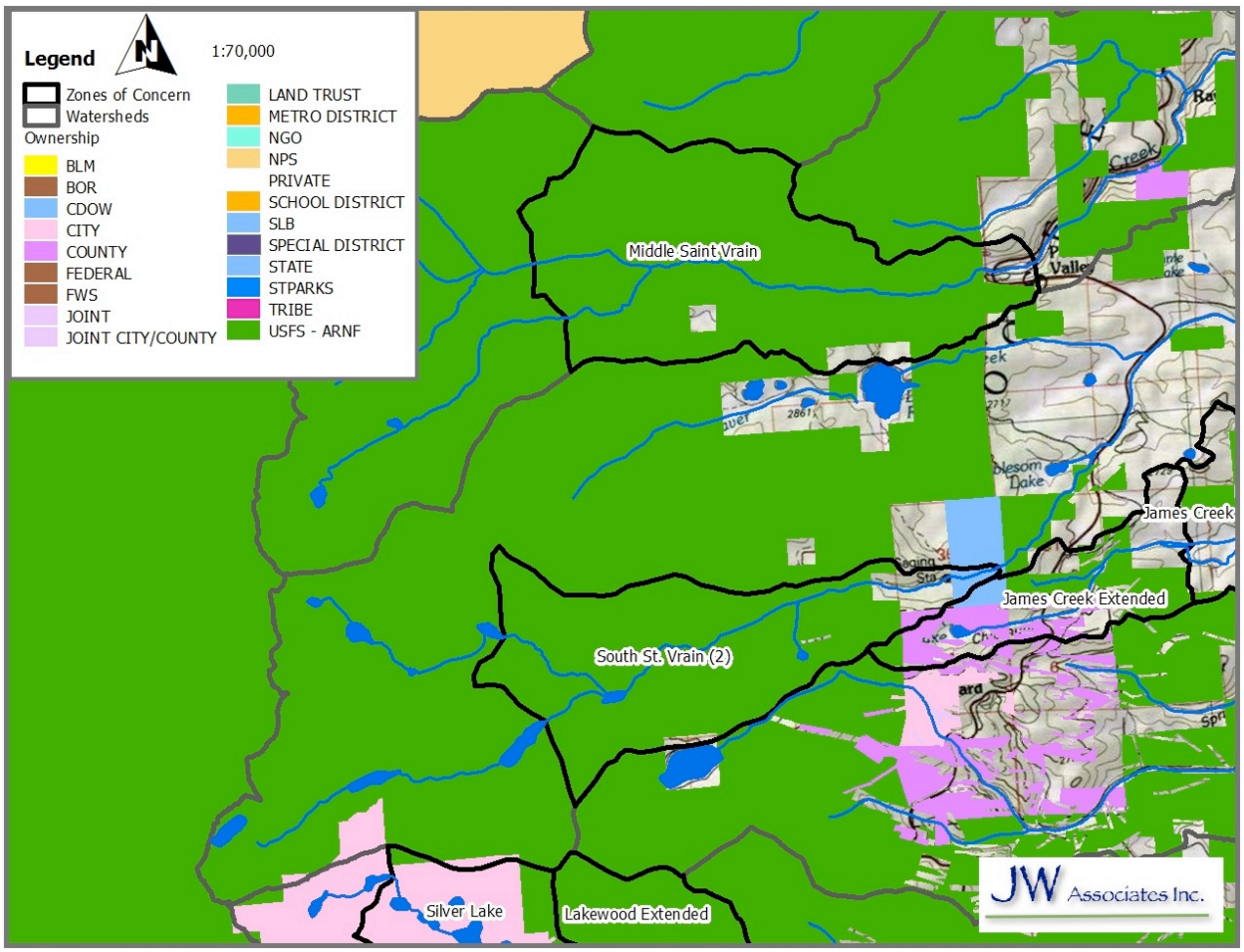


Figure 24. Middle Saint Vrain ZoC Ownership

Middle Saint Vrain Watershed Priority

The Middle Saint Vrain Creek watershed is ranked as Blue (Category 2) overall. It is also ranked as Orange (Category 4) for Flooding/Debris Flow Hazard (Figure 25). The Headwaters South Saint Vrain Creek watershed is ranked as Yellow (Category 3) overall. It is also ranked as Orange (Category 4) for Wildfire Hazard and Flooding/Debris Flow Hazard (Figure 25). The James Creek watershed is ranked as Orange (Category 4) overall, Wildfire Hazard, Flooding/Debris Flow Hazard, and Composite Hazard.

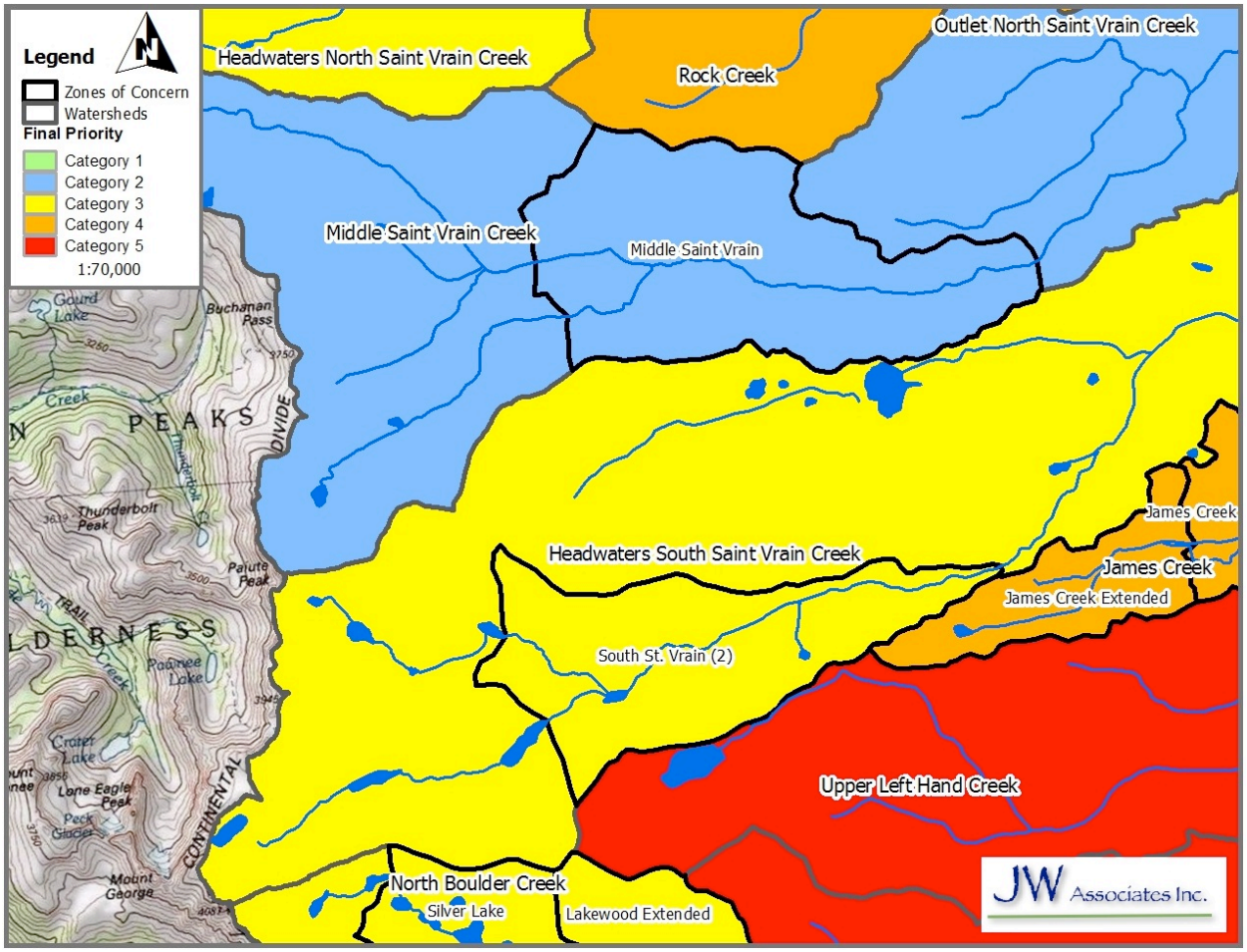


Figure 25. Middle Saint Vrain ZoC Watershed Priority

Middle Saint Vrain Slopes

The South Saint Vrain (2) ZoC is almost entirely shallow slopes (Figure 26). The James Creek Extended ZoC is also mostly shallow slopes. The Middle Saint Vrain ZoC has some steep slopes surrounding the main streams and in several bands at upper elevations (Figure 26).

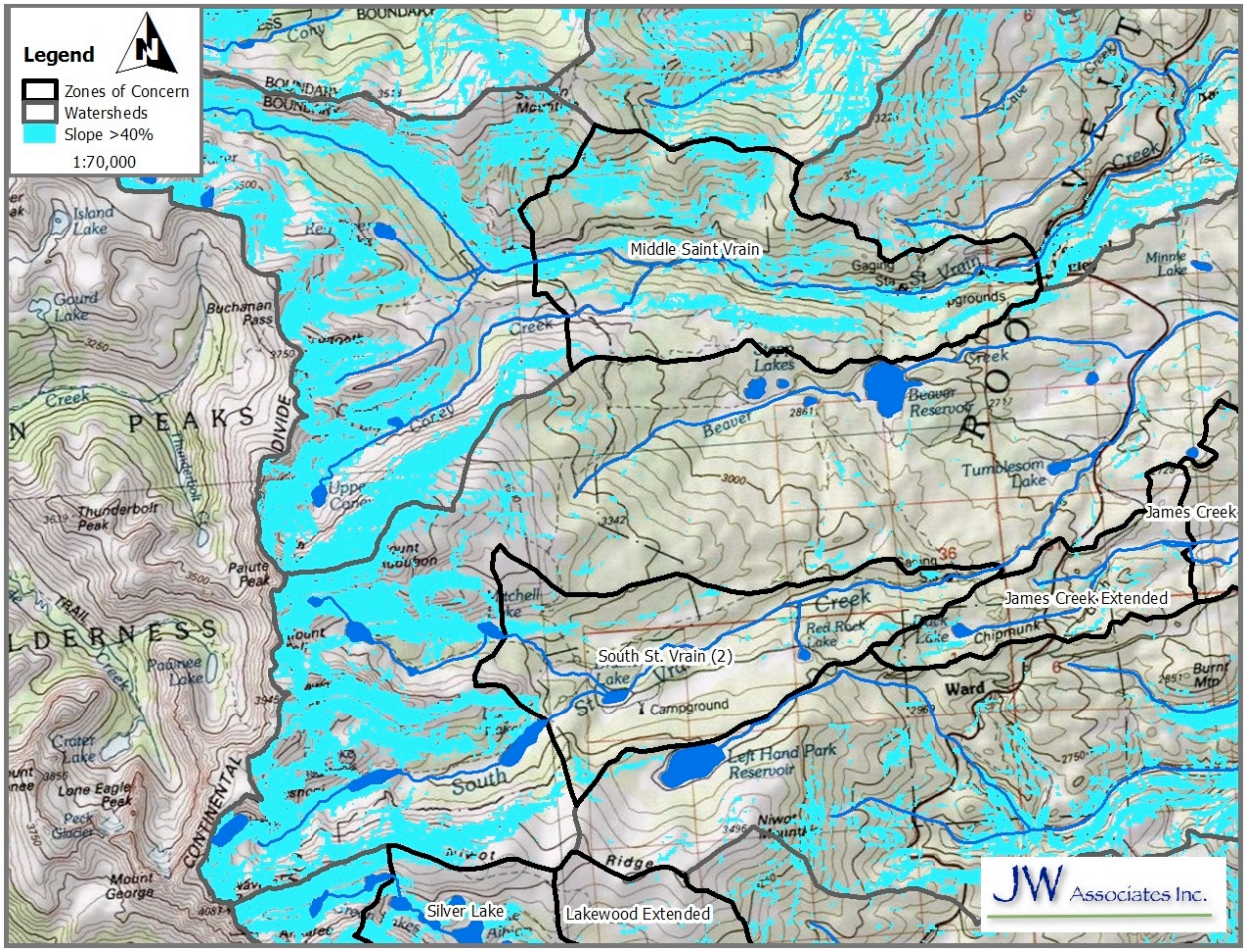


Figure 26. Middle Saint Vrain ZoC Slope

Middle Saint Vrain Special Management Areas

The Middle Saint Vrain ZoC is covered by the Indian Peaks Wilderness and the Indian Peaks Adjacent Roadless Areas north of the stream (Figure 27). The South Saint Vrain (2) ZoC also has large areas covered by the Indian Peaks Wilderness and the Indian Peaks Adjacent Roadless Areas but has some areas without those designations along the stream and the eastern portion. The James Creek Extended ZoC has only one small area in the western portion designated as roadless (Figure 27).

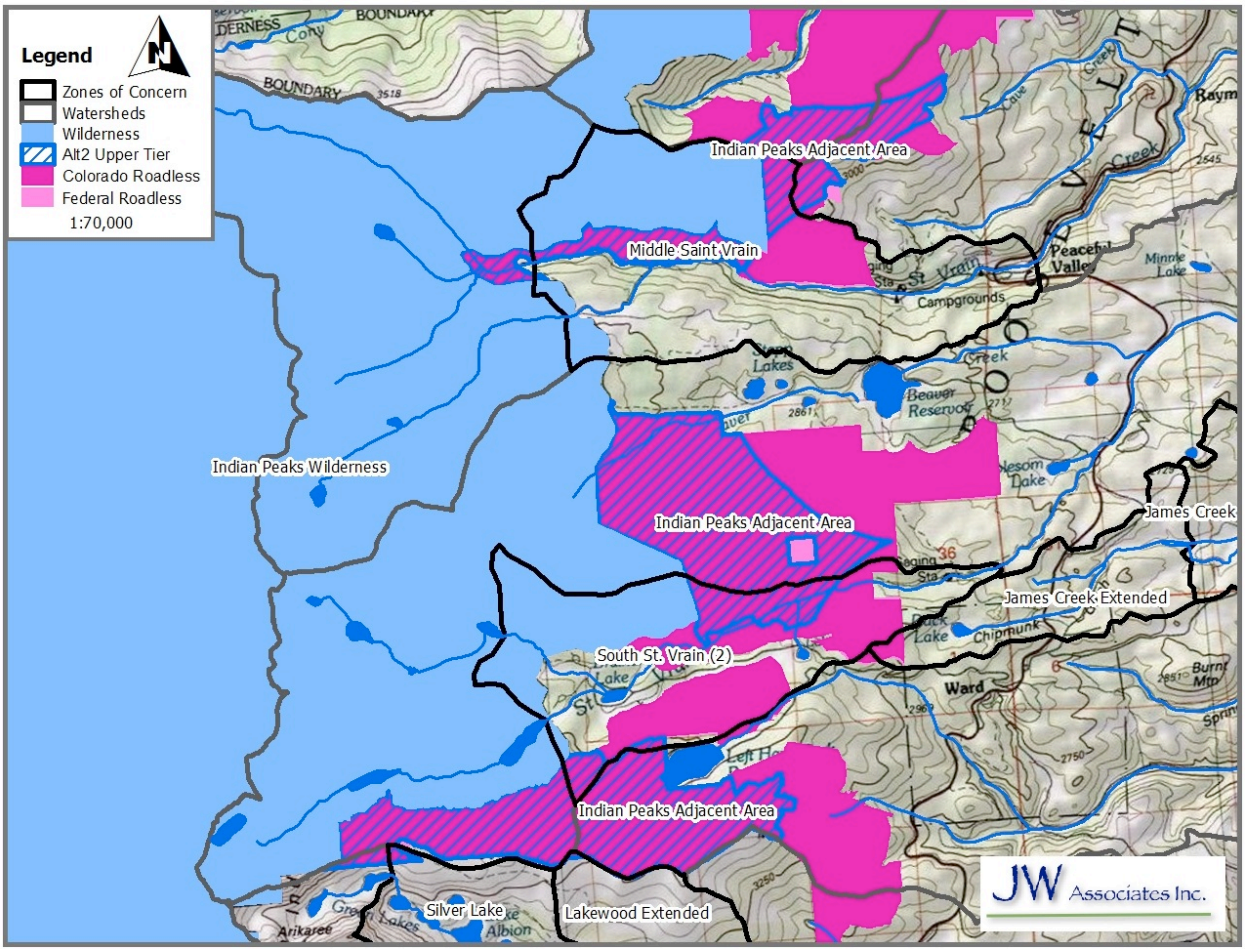


Figure 27. Middle Saint Vrain ZoC Special Areas

Middle Saint Vrain Vegetation

The South Saint Vrain (2) ZoC is dominated by spruce-fir, with some small areas of alpine high in the ZoC and some areas of lodgepole pine lower in the ZoC (Figure 28). The Middle Saint Vrain ZoC is dominated by lodgepole pine with some areas of aspen mixed in. There are also some areas of alpine vegetation at the highest elevations (Figure 28). The James Creek Extended ZoC is dominated by lodgepole pine with some large areas of aspen.

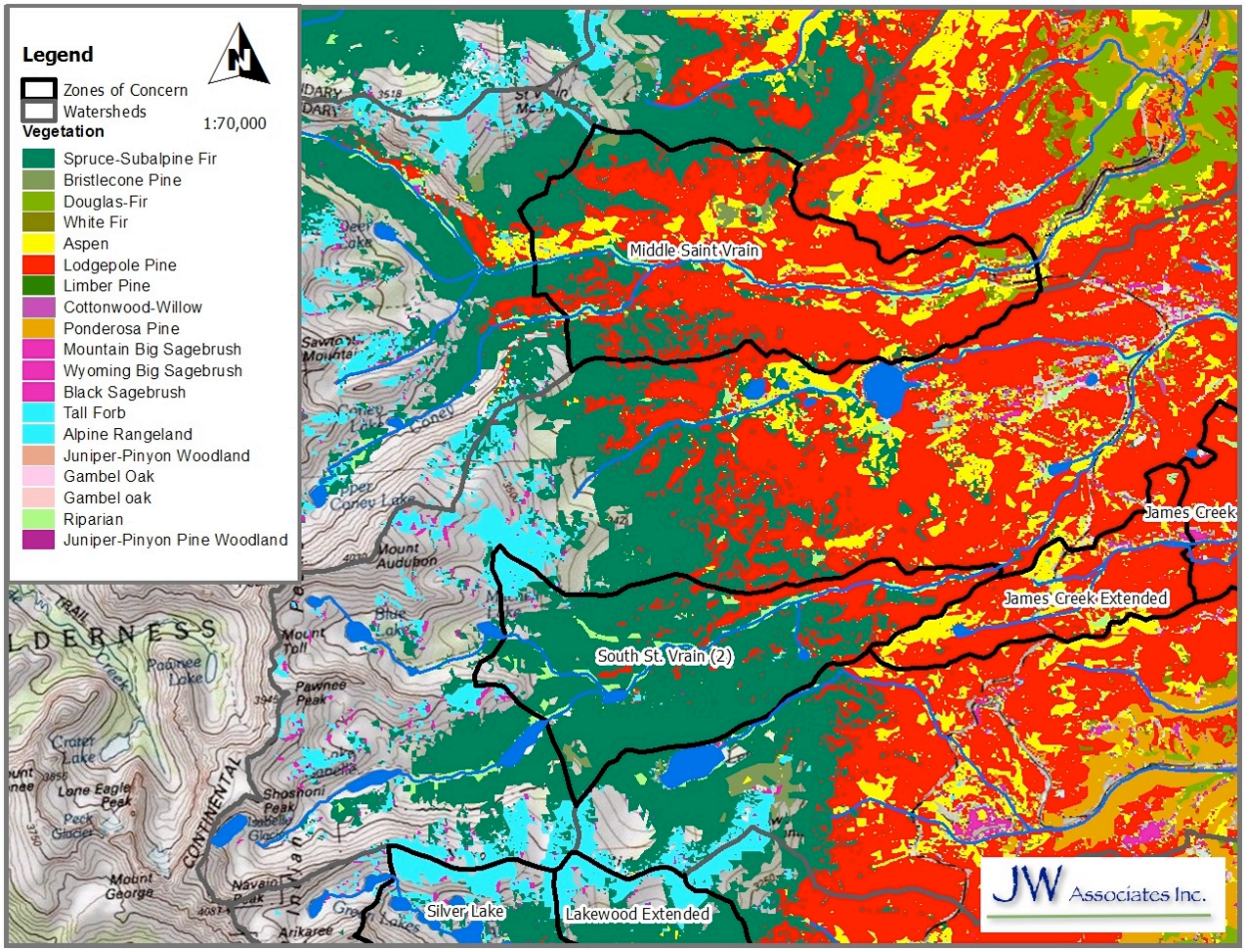


Figure 28. Middle Saint Vrain ZoC Vegetation

Middle Saint Vrain Past Fires

There are no recent past fires that have been mapped within these ZoC (figure 29). The Beaver Reservoir Fire burned in 1978 between the Middle Saint Vrain and South Saint Vrain (2) ZoC. It appears to have burned in mostly in lodgepole pine.

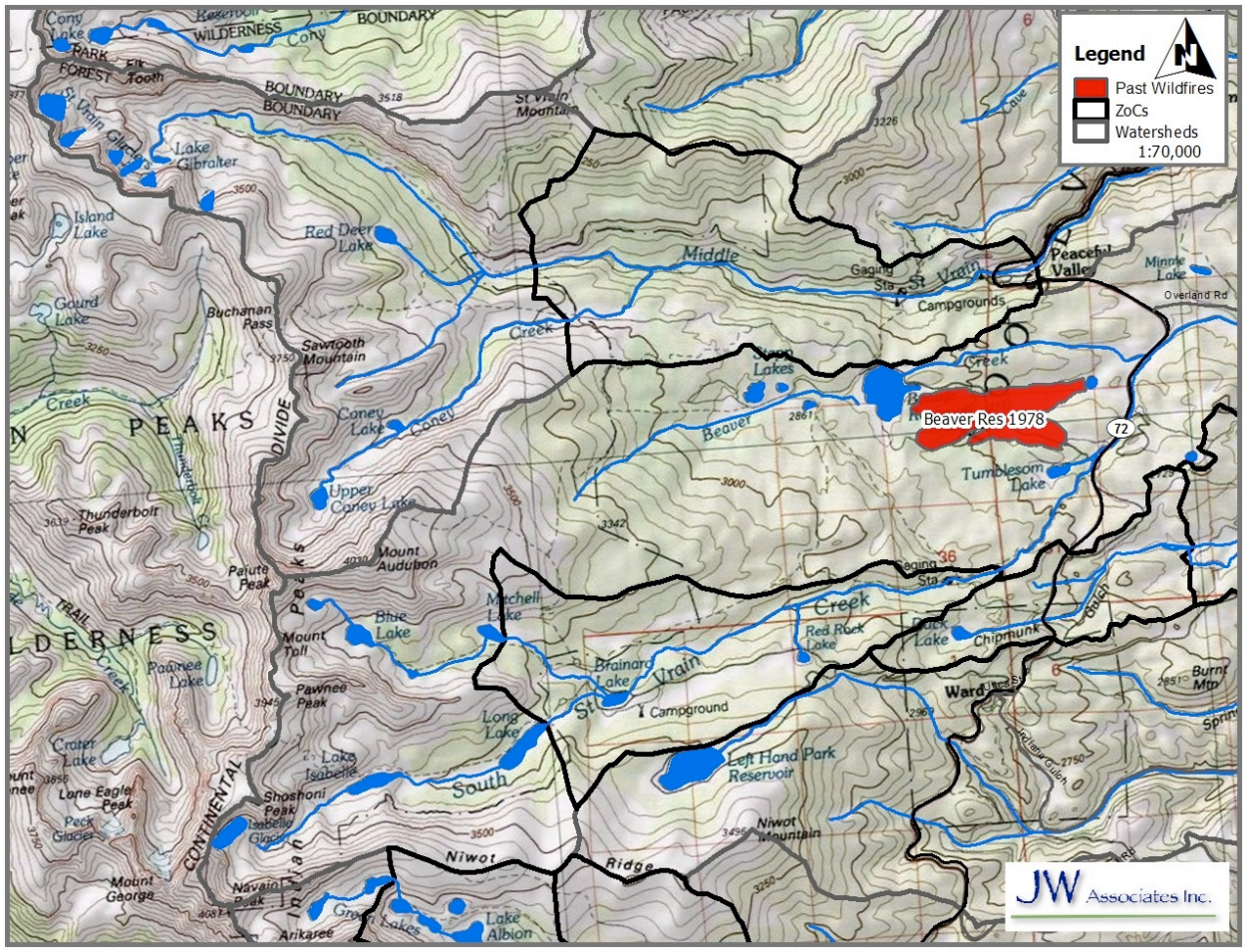


Figure 29. Middle Saint Vrain ZoC Past Fires

Middle Saint Vrain Access

There are many existing roads in the James Creek Extended ZoC (Figure 30). Access to the South Saint Vrain (2) ZoC is limited to one access road running next to the stream. The Middle Saint Vrain ZoC has some access from two roads - one on each side of the stream.

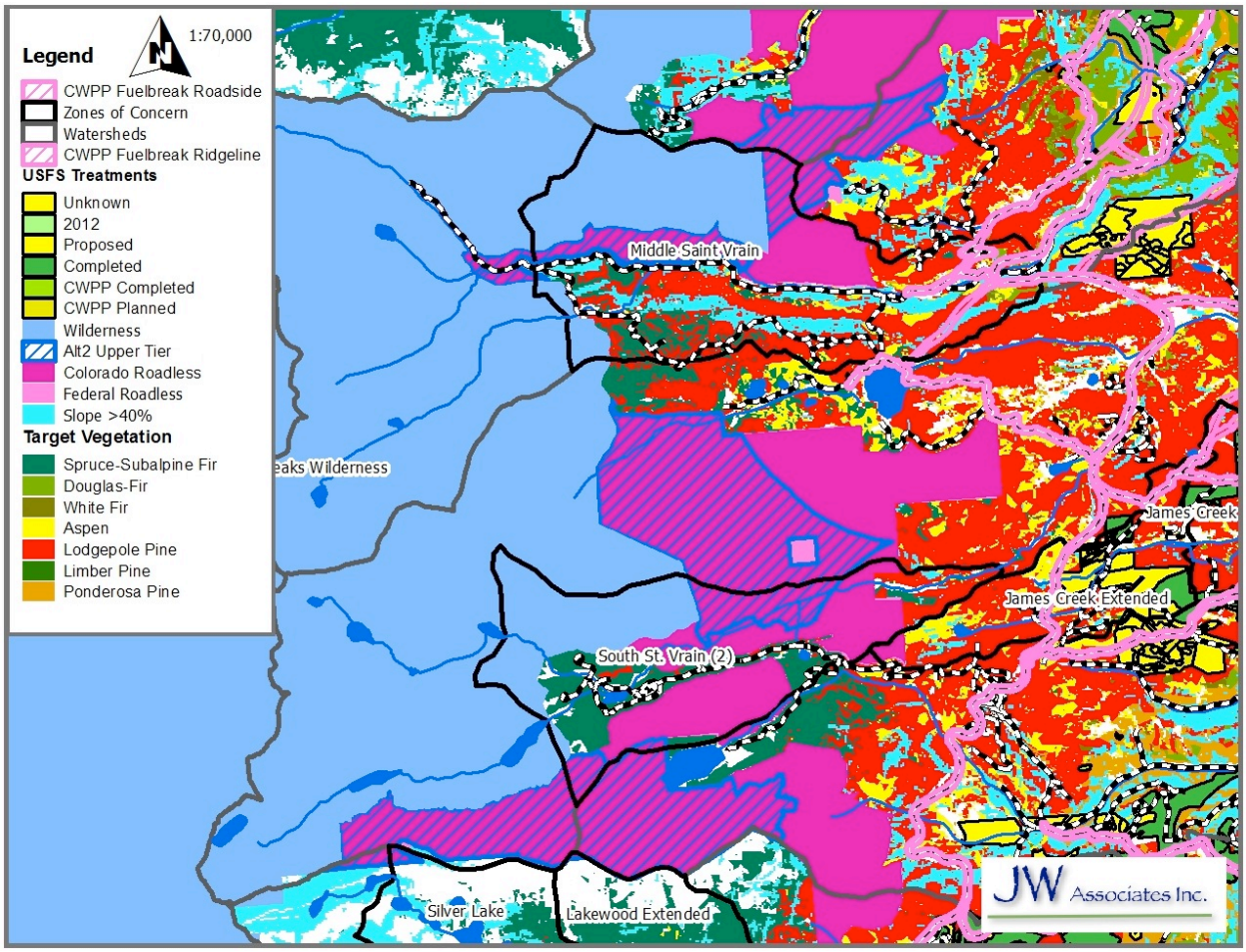


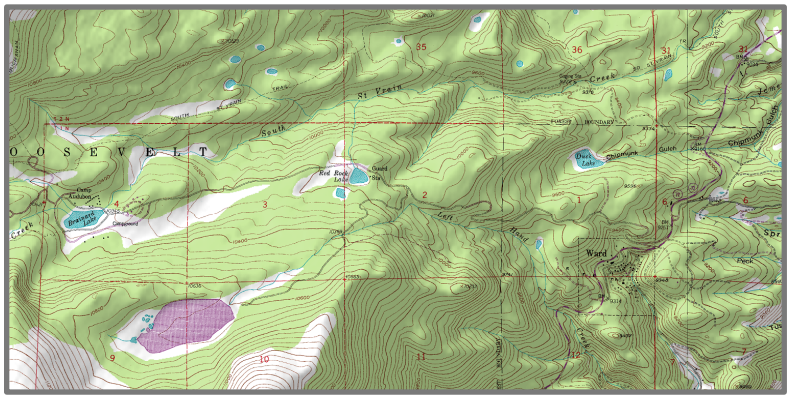
Figure 30. Middle Saint Vrain ZoC Opportunities

Middle Saint Vrain Opportunities

Management opportunities are highly constrained because of the extensive amounts of wilderness and roadless designations within the Middle St. Vrain and South St. Vrain (2) ZoC. 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. Work with the US Forest

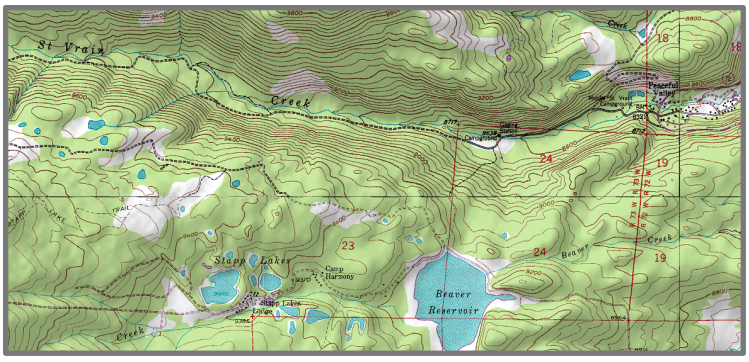
Service to develop and implement realistic fire management plans that could allow natural fires of lower intensities to burn within these watersheds to create greater diversity and reduce fuels.

Slopes are constraining within portions of the Middle St. Vrain ZoC, but road access via Beaver Reservoir provides an opportunity to treat fuels in some of the higher elevations. Harvesting equipment not traditionally used in Colorado, such as cable yarding, could also be used to treat steep slopes to the north of this access road. Roadside and Ridgetop fuelbreaks are proposed in the Boulder County CWPP for the eastern portion of this ZoC, and a significant area of treatment is planned immediately east of Peaceful Valley, outside the ZoC; but few other treatments are currently proposed. Work with the owners of Peaceful Valley to develop defensible space around their structures and to inform visitors about the importance of the area's watersheds and the danger of wildfire to water quality.



Within the South St. Vrain (2) ZoC there are management opportunities at the extreme east end of the Zoc and along the road corridor that leads to Red Rock Lake and Brainard Lake. Slopes are quite operable and access is good. Work with the Town of Ward to implement fuel hazard treatments in and around the town to help prevent fires from moving upslope and into the ZoC.

Many treatments are proposed or planned for the east end of the James Creek Extended ZoC as shown on Figure 30 and listed in the Boulder County CWPP. Review any local CWPPs and work closely with local Fire Protection Districts to implement their plans. Supporting development of comprehensive, community-based defensible space installation can help prevent structure fires from moving into the forest and upslope into the watersheds. Few treatments are currently planned for the western end of the ZoC. Work with Boulder County and the Colorado State Forest Service to develop treatment plans for County and State lands. Work with the Town of Ward to implement fuel hazard treatments in and around the town to help prevent fires from moving into the ZoC.



North Boulder Creek Area ZoC

The Silver Lake, Lakewood Reservoir, Lakewood Reservoir Extended, North Boulder Creek, and North Boulder Extended ZoC are combined in this section because they are adjacent and, in some locations, overlapping (Figure 31). Note that the ZoC are shown here in pink with crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

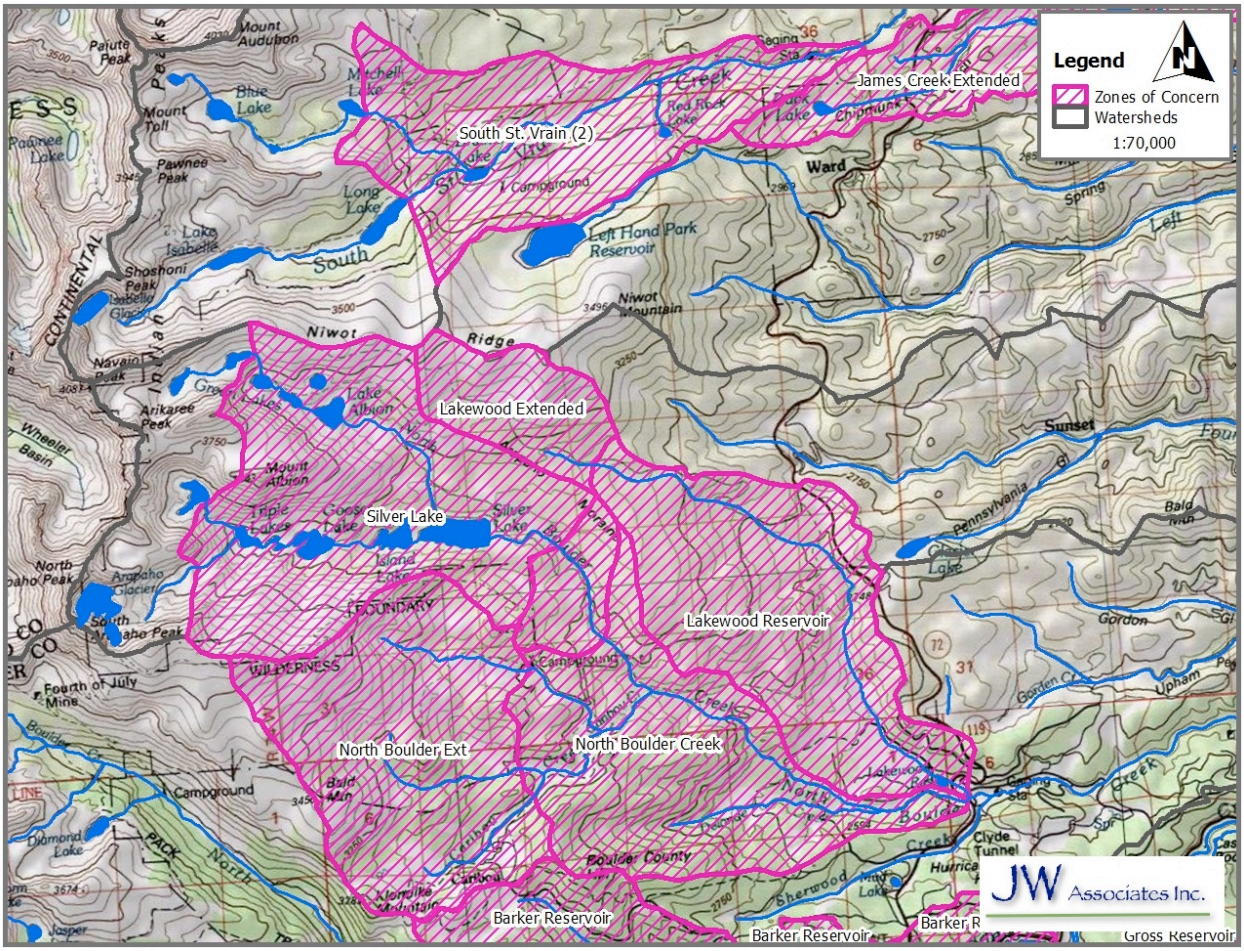


Figure 31. North Boulder Creek ZoC Location

North Boulder Creek Ownership

The Silver Lake ZoC is mostly on City of Boulder lands (Figure 32). The majority of the North Boulder Creek ZoC is on Boulder County Open Space lands with some NFS and City of Boulder lands. The North Boulder Extended and Lakewood Extended ZoC are nearly all on NFS lands. The Lakewood Reservoir ZoC is mostly private lands in the lowest portions and mostly NFS lands in the upper portions. There are also some areas of Boulder County Open Space and Colorado State Land Board lands in the Lakewood Reservoir ZoC (Figure 32).

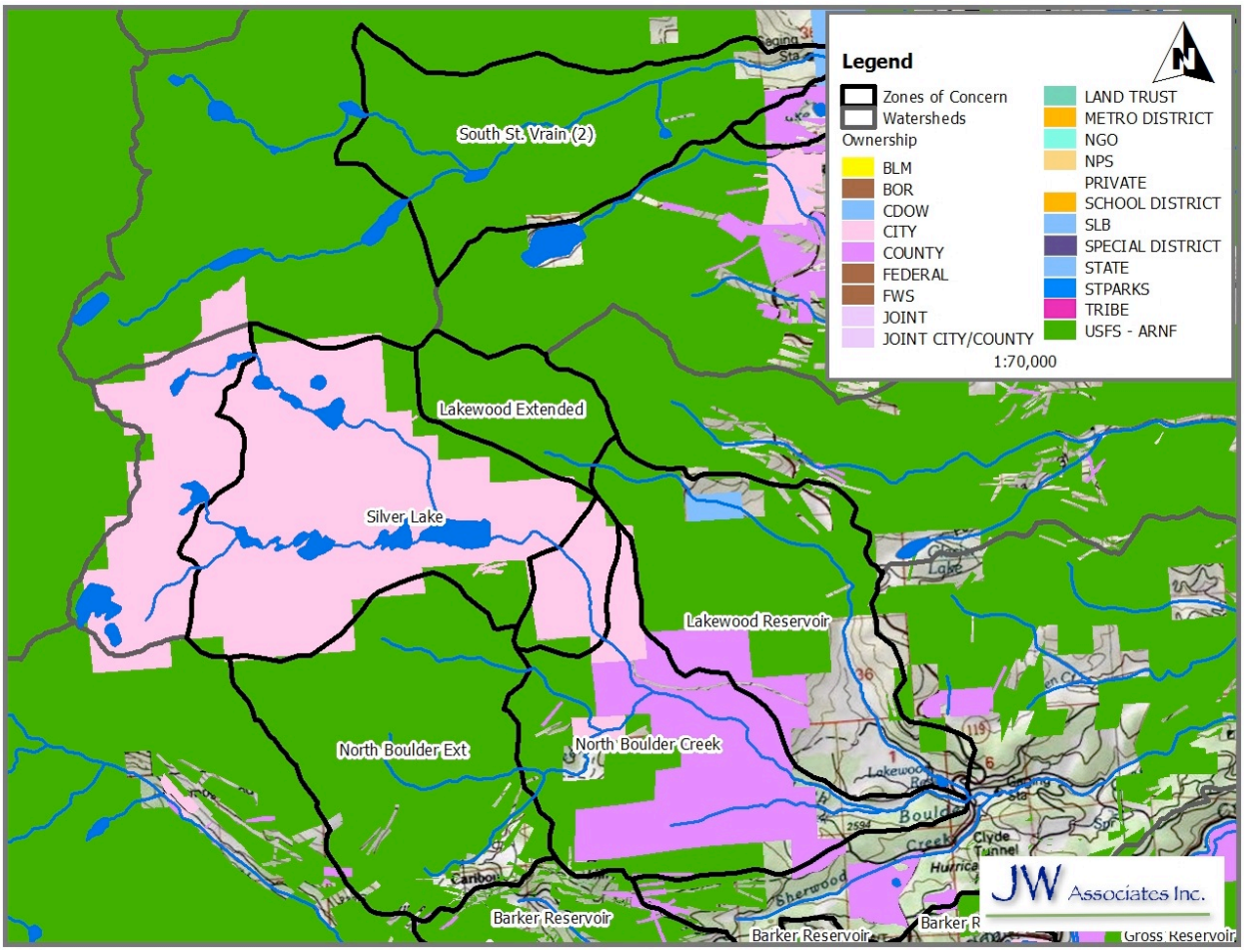


Figure 32. North Boulder Creek ZoC Ownership

North Boulder Creek Watershed Priority

The North Boulder Creek watershed is ranked as Yellow (Category 3) overall (Figure 33). It is also ranked as Orange (Category 4) for Flooding/Debris Flow Hazard.

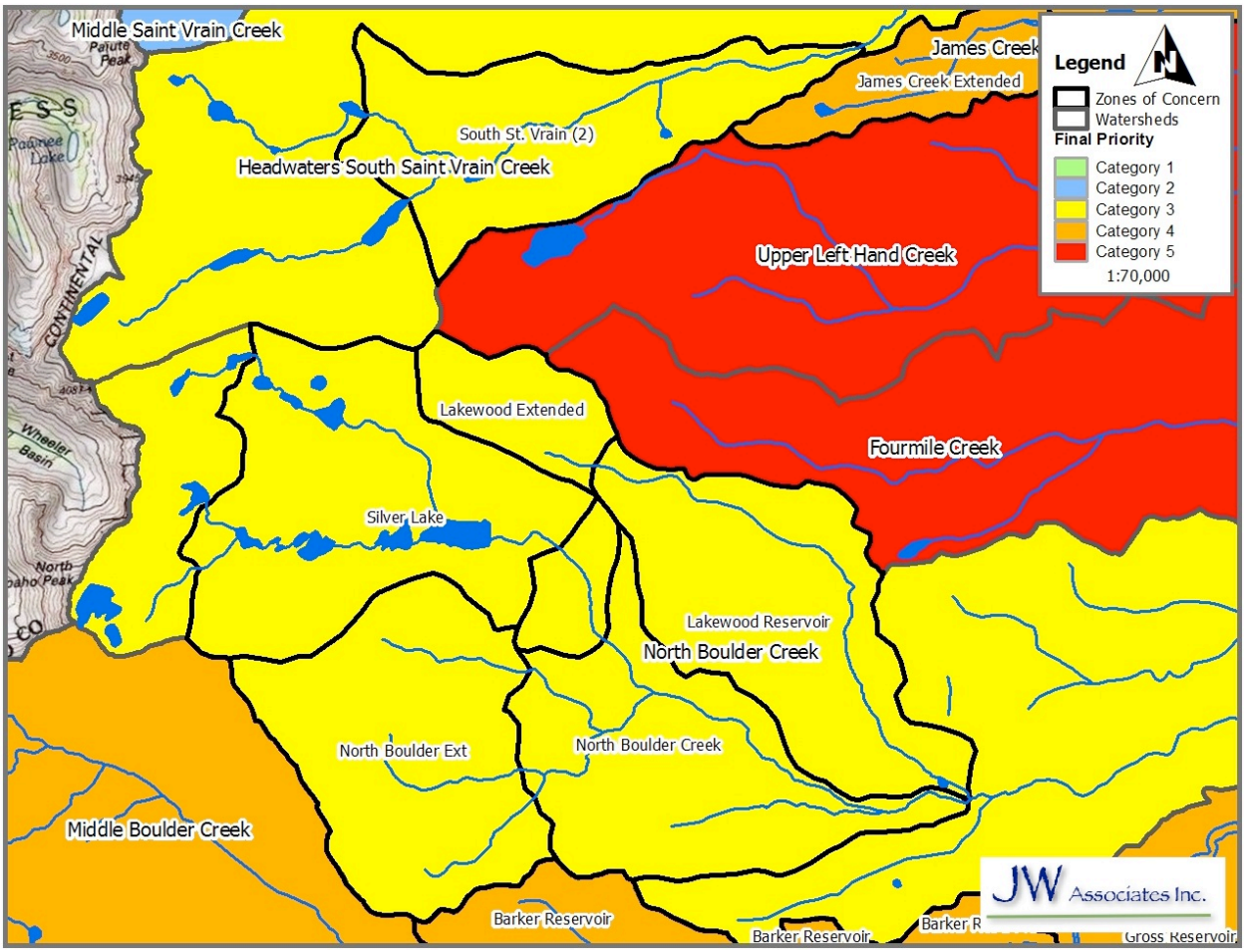


Figure 33. North Boulder Creek ZoC Watershed Priority

North Boulder Creek Slopes

The North Boulder Creek and North Boulder Extended ZoC have mostly shallow slopes with steeper slopes surrounding the stream channels (Figure 34). The Lakewood Reservoir and Lakewood Extended ZoC have mostly shallow slopes with some small areas of steeper slopes in the lowest portions surrounding stream channels (Figure 34).

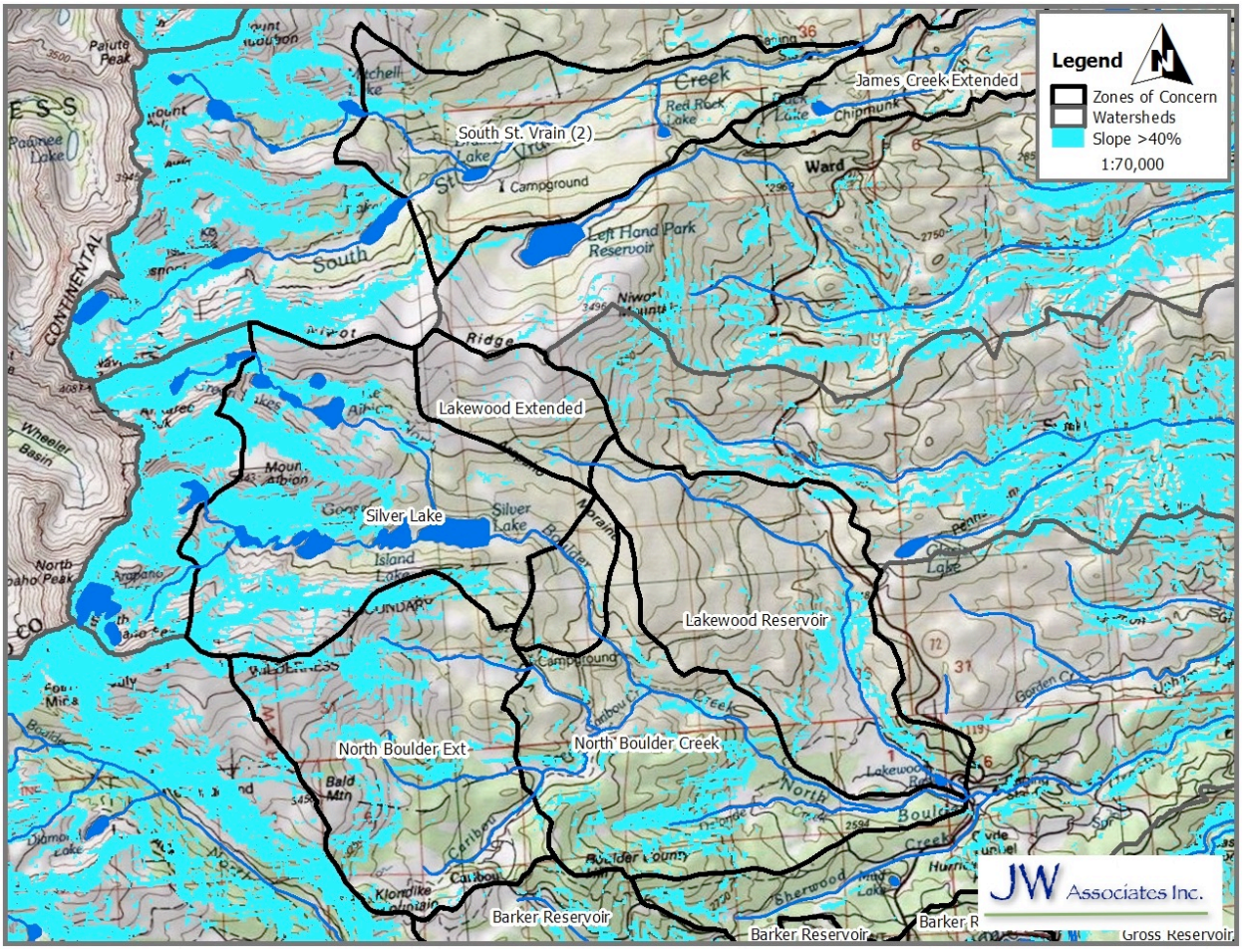


Figure 34. North Boulder Creek ZoC Slope

North Boulder Creek Special Management Areas

The Lakewood Reservoir and Lakewood Extended ZoC have no special designations (Figure 35). The North Boulder Creek ZoC has a small area covered by the Indian Peaks Adjacent Roadless Areas. The North Boulder Extended ZoC is mostly covered by the Indian Peaks Wilderness Area. The Silver Lake ZoC has only one small area covered by the Indian Peaks Wilderness Area (Figure 35).

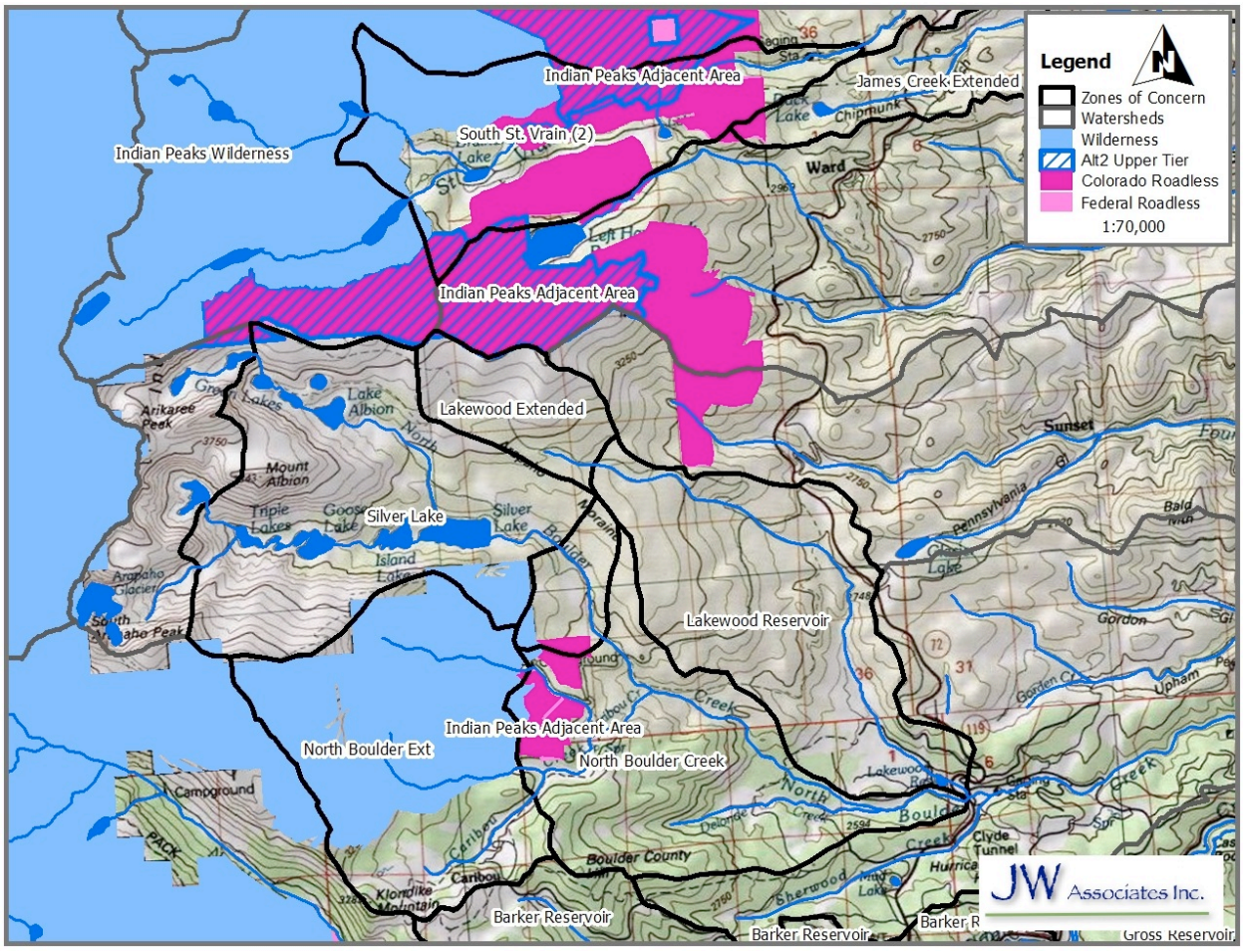


Figure 35. North Boulder Creek ZoC Special Areas

North Boulder Creek Vegetation

The Lakewood Reservoir and North Boulder Creek ZoC are mostly lodgepole pine with some significant areas of aspen scattered throughout (Figure 36). These ZoC begin with some areas of ponderosa pine at the lowest elevations and end with some areas of spruce-fir at the highest elevations. The Lakewood Extended ZoC is mostly spruce-fir, with some alpine areas at the highest elevations. The North Boulder Extended ZoC contains some areas of lodgepole pine mixed with aspen lower in the ZoC, and then transitions quickly to large areas of spruce-fir and some large areas of alpine. The Silver Lake ZoC is mostly spruce-fir with some large areas of aline high in the ZoC and some small areas of lodgepole lower in the ZoC (Figure 36).

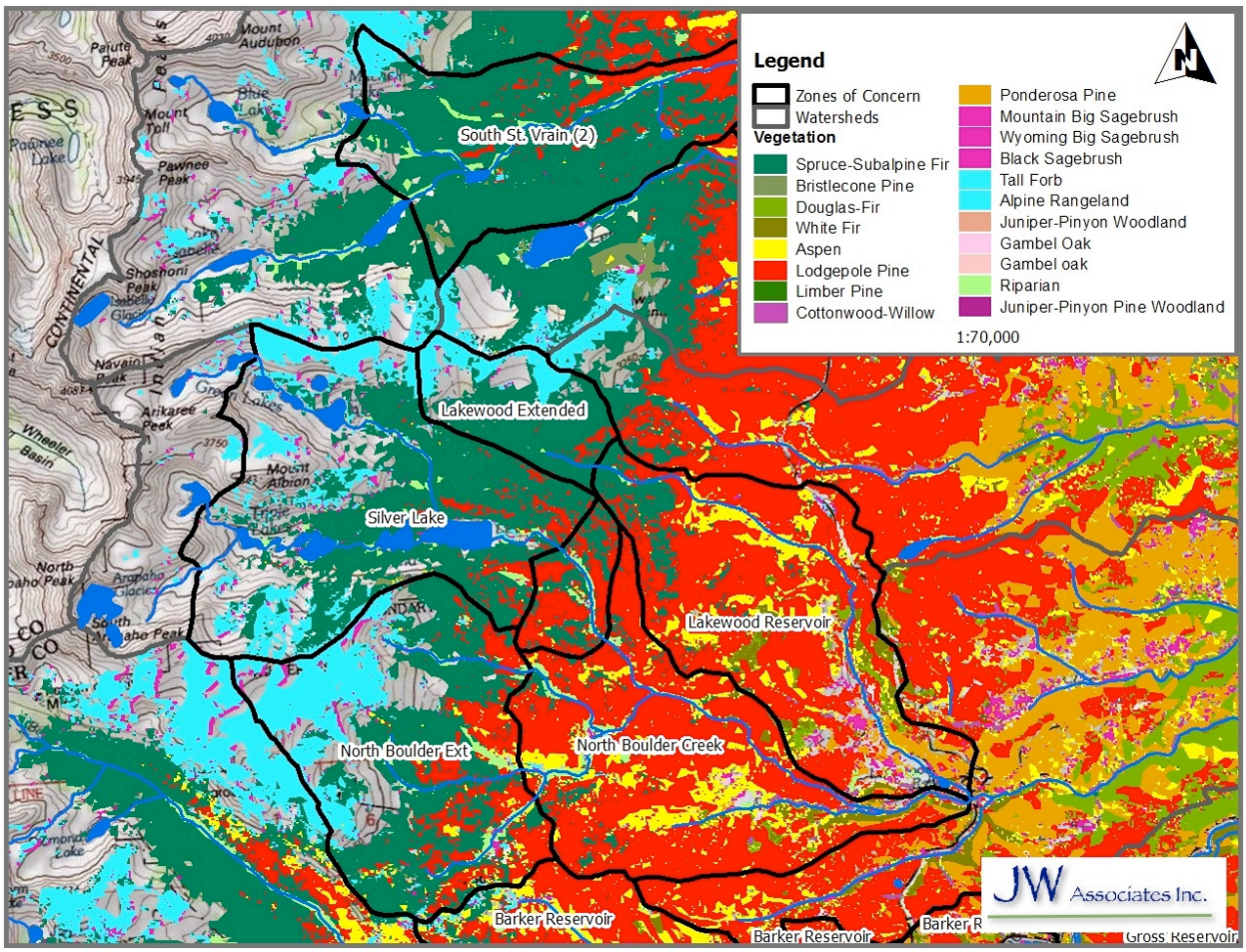


Figure 36. North Boulder Creek ZoC Vegetation

North Boulder Creek Past Fires

There are no recent past fires that have been mapped within or adjacent to these ZoC (figure 37).

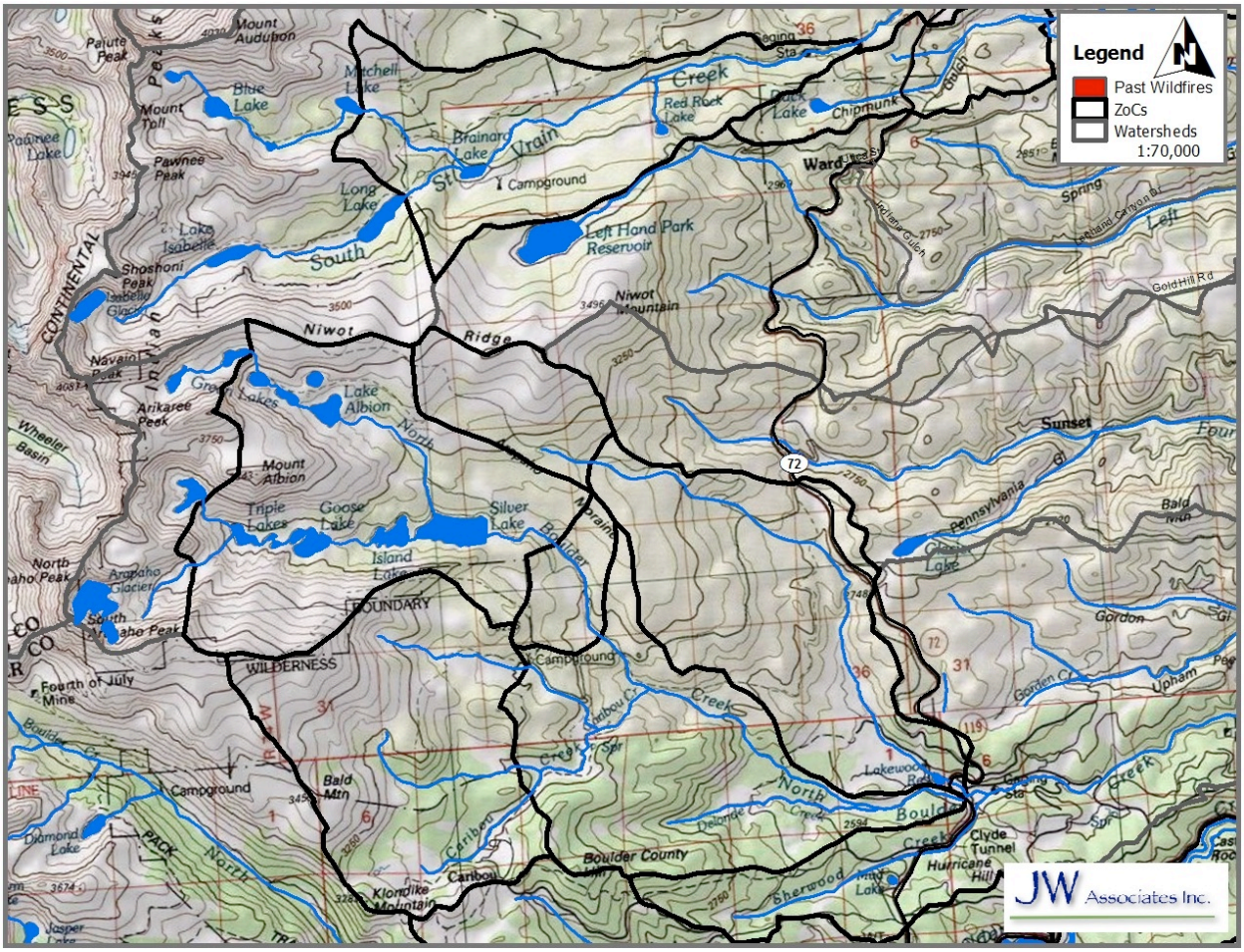


Figure 37. North Boulder Creek ZoC Past Fires

North Boulder Creek Access

There are several existing roads that provide some access to the Lakewood Reservoir and North Boulder Creek ZoC (Figure 38). Access to the North Boulder Extended ZoC is limited to the southern portion only. The Silver Lake ZoC only has access to the lake. The Lakewood Extended ZoC has no existing access roads.

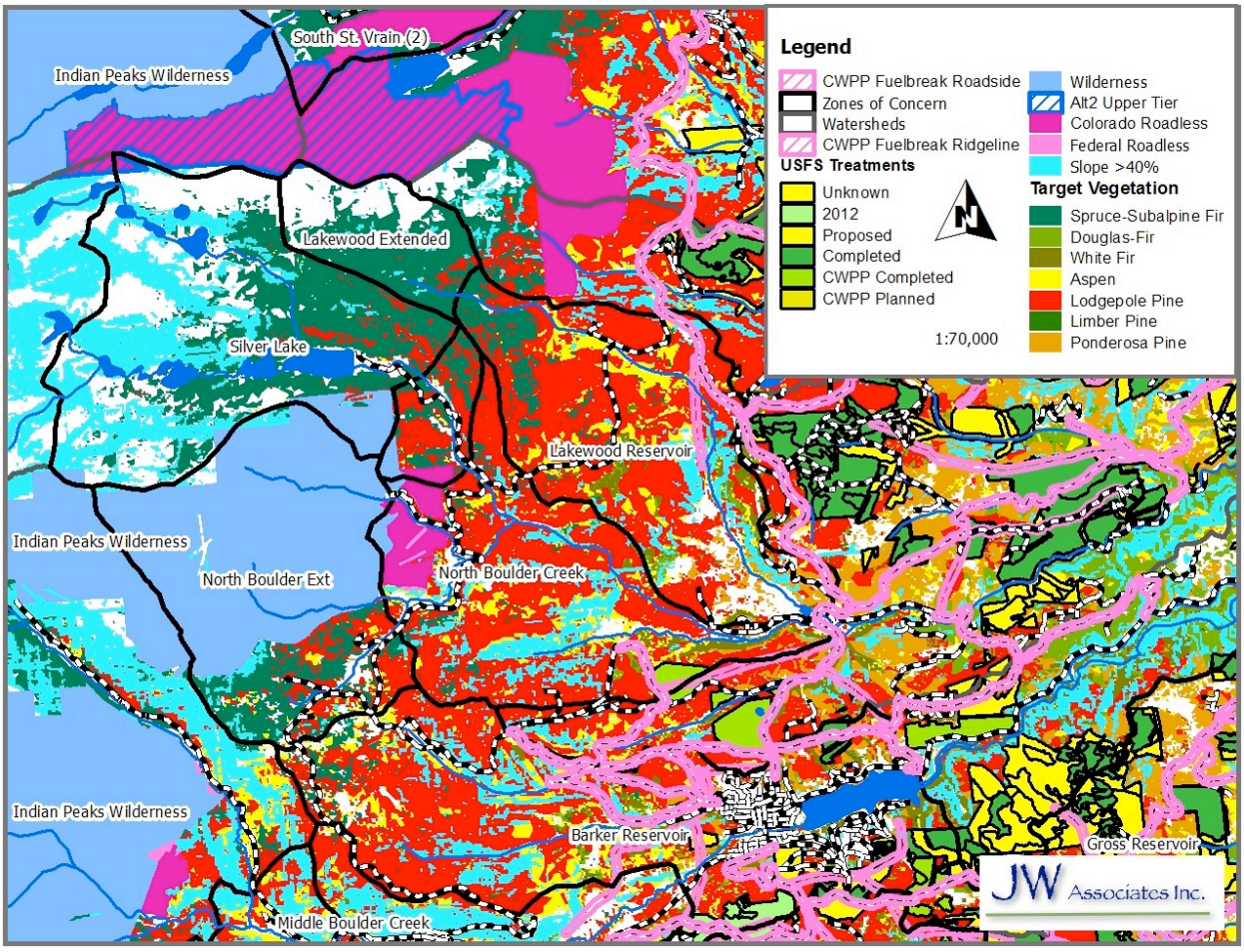


Figure 38. North Boulder Creek ZoC Opportunities

North Boulder Creek Opportunities

Mechanical treatments in portions of these ZoC are constrained or limited by wilderness and roadless designations, but those designations cover relatively small areas. There are some large areas with operable slopes with county and city ownership that provide ample opportunities for fuel hazard reduction treatments. Develop an information and education plan in conjunction with the US Forest Service to inform hikers 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. Work with the US Forest Service to develop and implement fire management plans that allow natural fires of lower intensities to burn within these watersheds to create greater diversity and reduce fuels.

Many treatments are proposed or planned east of the Lakewood ZoC but not in the ZoC. There is also one project on the south side of the North Boulder Creek ZoC as shown on Figure 38 and listed in Boulder County CWPP. Review any local CWPPs and work closely with local Fire Protection Districts to implement their plans. Supporting development of comprehensive, community-based defensible space installation can help prevent structure fires from moving into the forest and upslope into the watersheds. Few treatments are currently planned for the western portions of the ZoC.; work with Boulder County and the City of Boulder to develop treatment plans for County and City lands.

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. 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. Maintain current aspen stands through protection, and where necessary, regeneration harvests. Where ponderosa pine exists, conduct restorations harvests and attempt to expand this species by favoring its retention when thinning mixed species stands.

Barker Reservoir ZoC

The Barker Reservoir, Middle Boulder Creek and Jenny Creek ZoC are adjacent or overlapping and are combined in this discussion (Figure 39). Note that the ZoC are shown here in pink or yellow crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

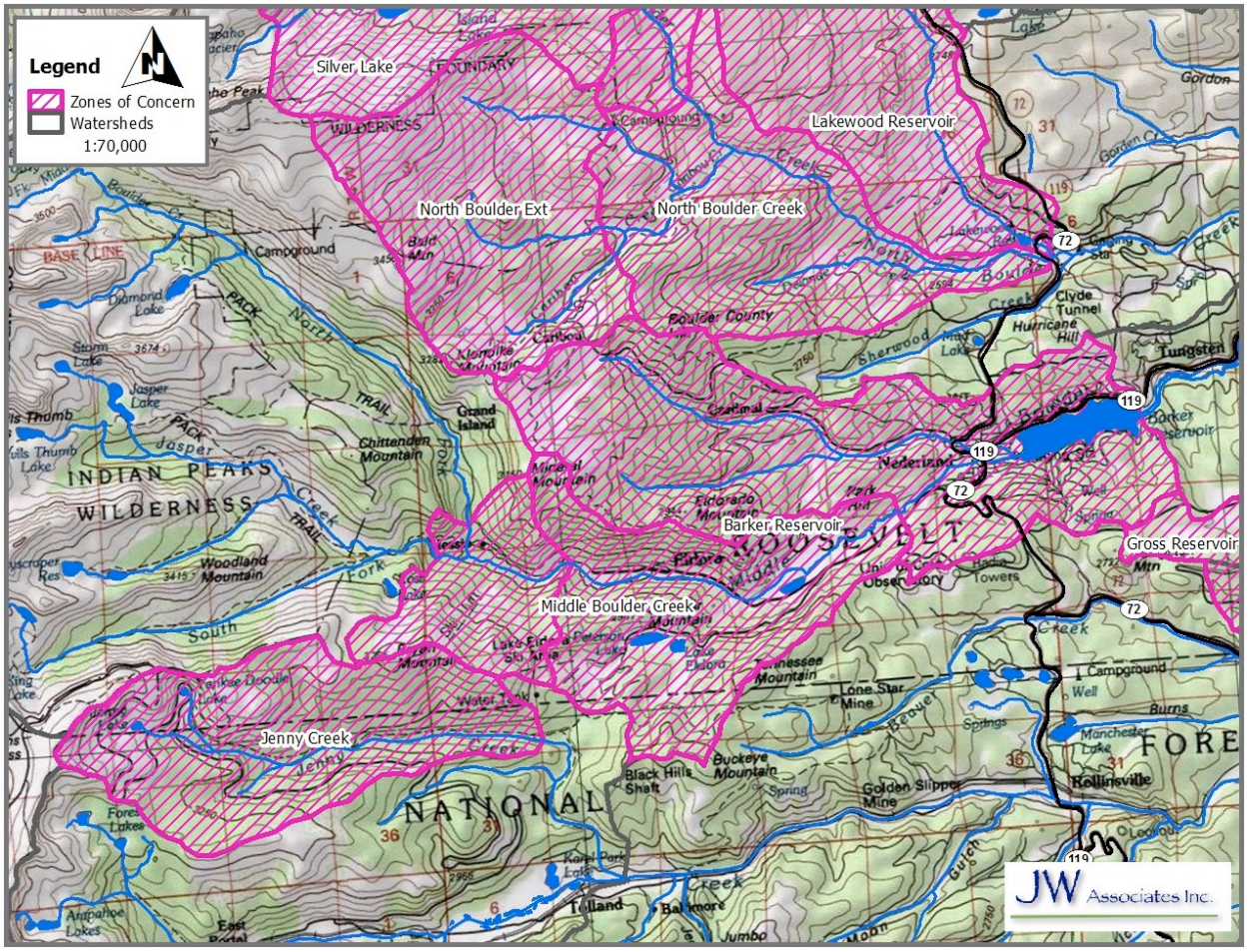


Figure 39. Barker Reservoir ZoC Location

Barker Reservoir ZoC Ownership

The Jenny Creek ZoC is nearly all NFS lands (Figure 40). The lower portions of the Barker Reservoir ZoC are mixed private, Boulder County Open Space and NFS lands, with private lands covering a large portion of the lower sections. The upper portions of the Barker Reservoir ZoC are dominated by NFS lands except for the area around Eldora Resort, which is private land. The ownership pattern for the Middle Boulder Creek ZoC is dominated by private lands in the lower portions and NFS lands in the upper portions (Figure 40).

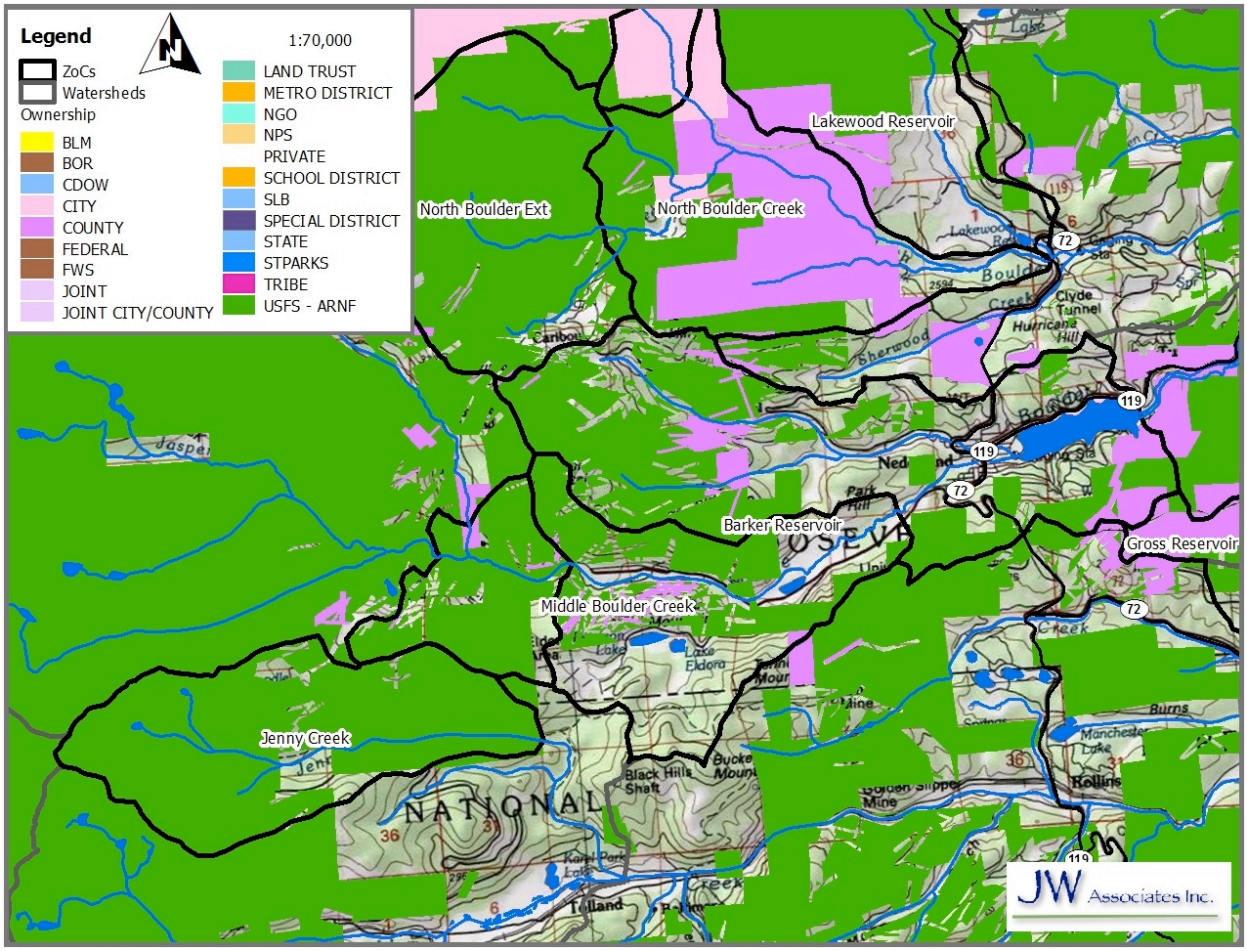


Figure 40. Barker Reservoir ZoC Ownership

Barker Reservoir ZoC Watershed Priority

The MIddle Boulder Creek watershed is ranked as Orange (Category 4) overall, and for Flooding/Debris Flow Hazard (Figure 41). The Headwaters South Boulder Creek watershed is ranked as Blue (Category 2) overall. It is also ranked as Orange (Category 4) for Wildfire Hazard (Figure 41).

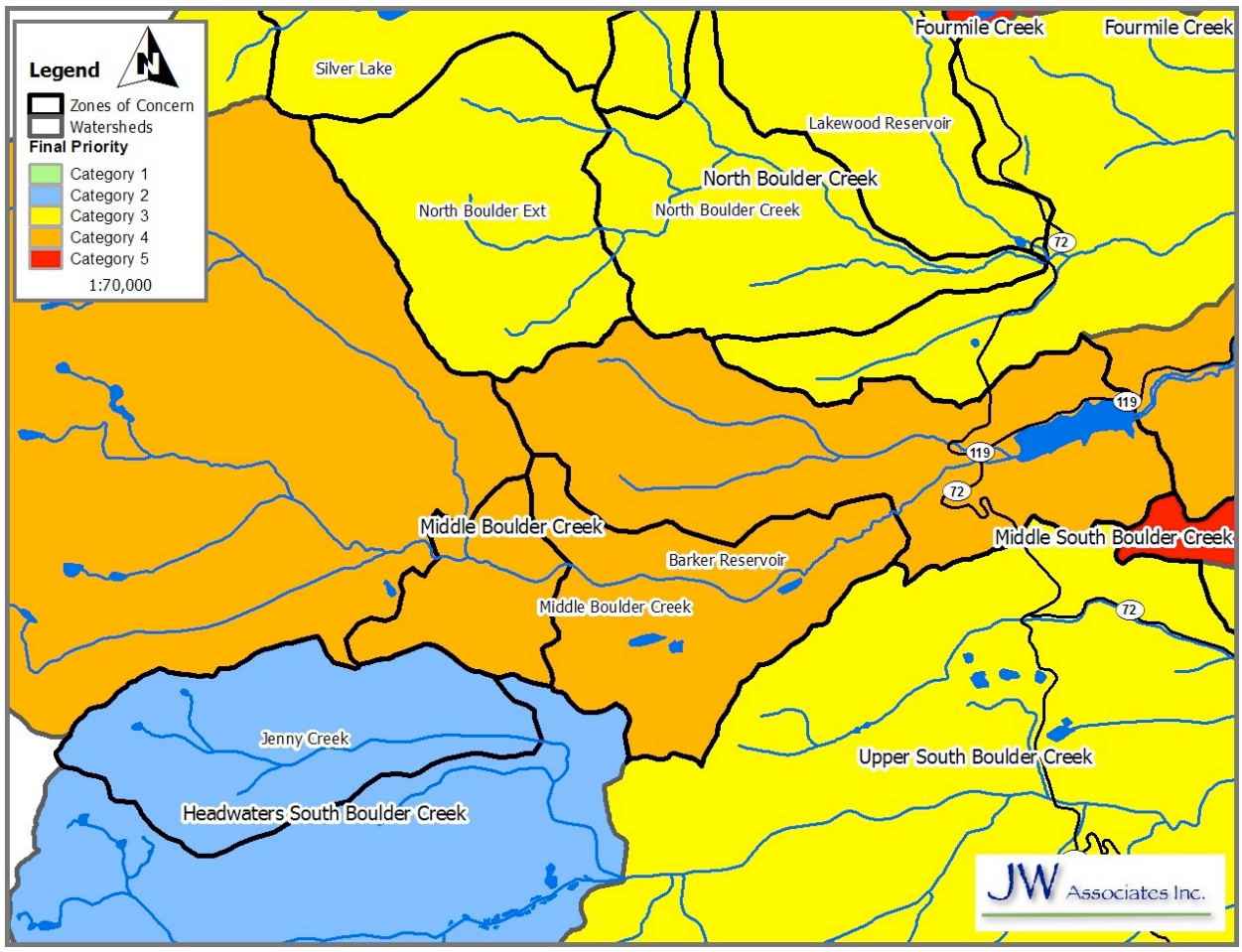


Figure 41. Barker Reservoir ZoC Watershed Priority

Barker Reservoir ZoC Slopes

The Barker Reservoir ZoC has large areas of shallow slopes especially in the eastern and northern portions (Figure 42). The Middle Boulder Creek ZoC has large areas of steep slopes with shallower slopes mostly in the Eldora Resort area in the southern portion. The Jenny Creek ZoC has mostly shallower slopes (Figure 42).

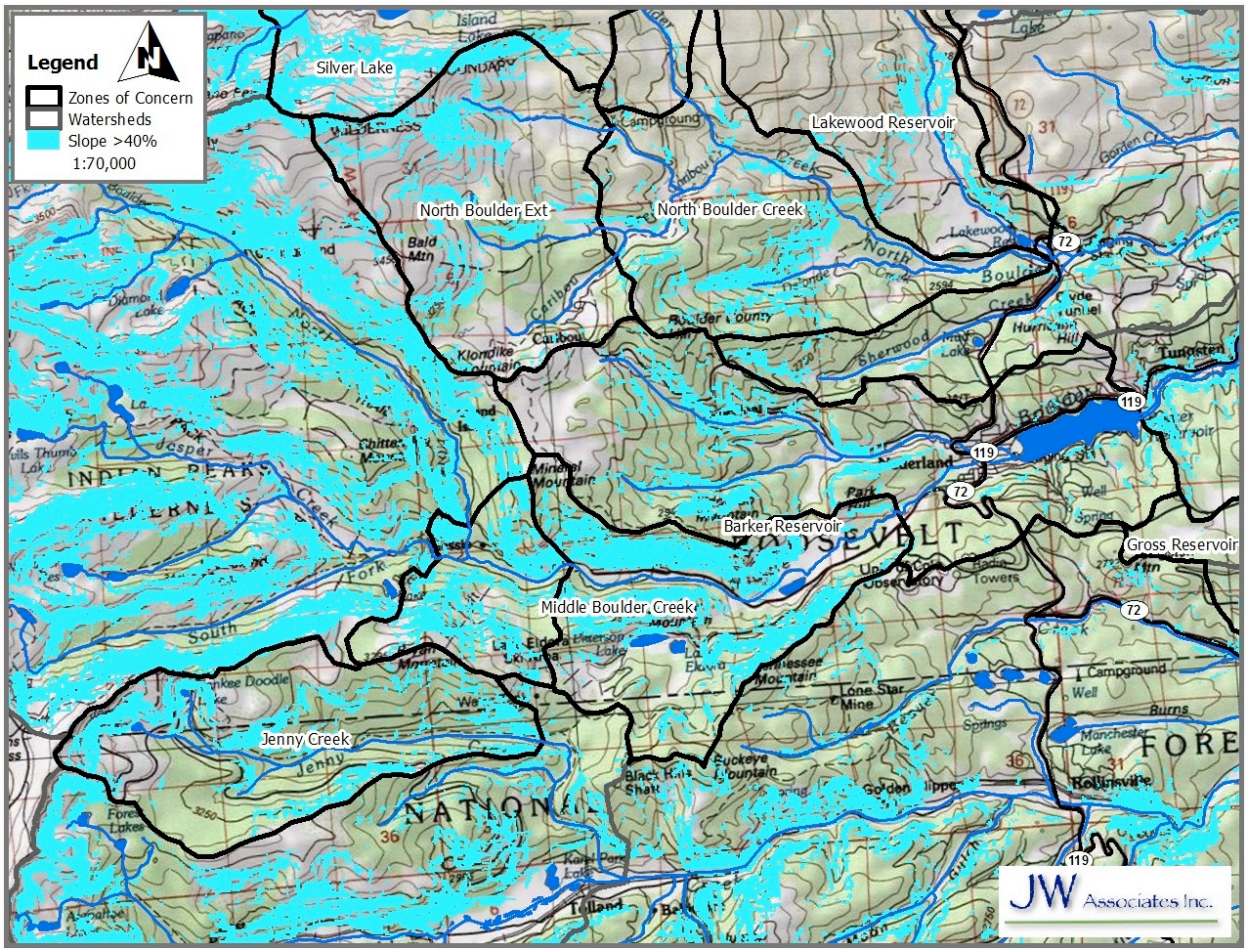


Figure 42. Barker Reservoir ZoC Slope

Barker Reservoir ZoC Special Management Areas

There are no special management areas in the Barker Reservoir and Middle Boulder Creek ZoC (Figure 43). The Jenny Creek ZoC has the Indian Peaks Wilderness Area covering the western portions.

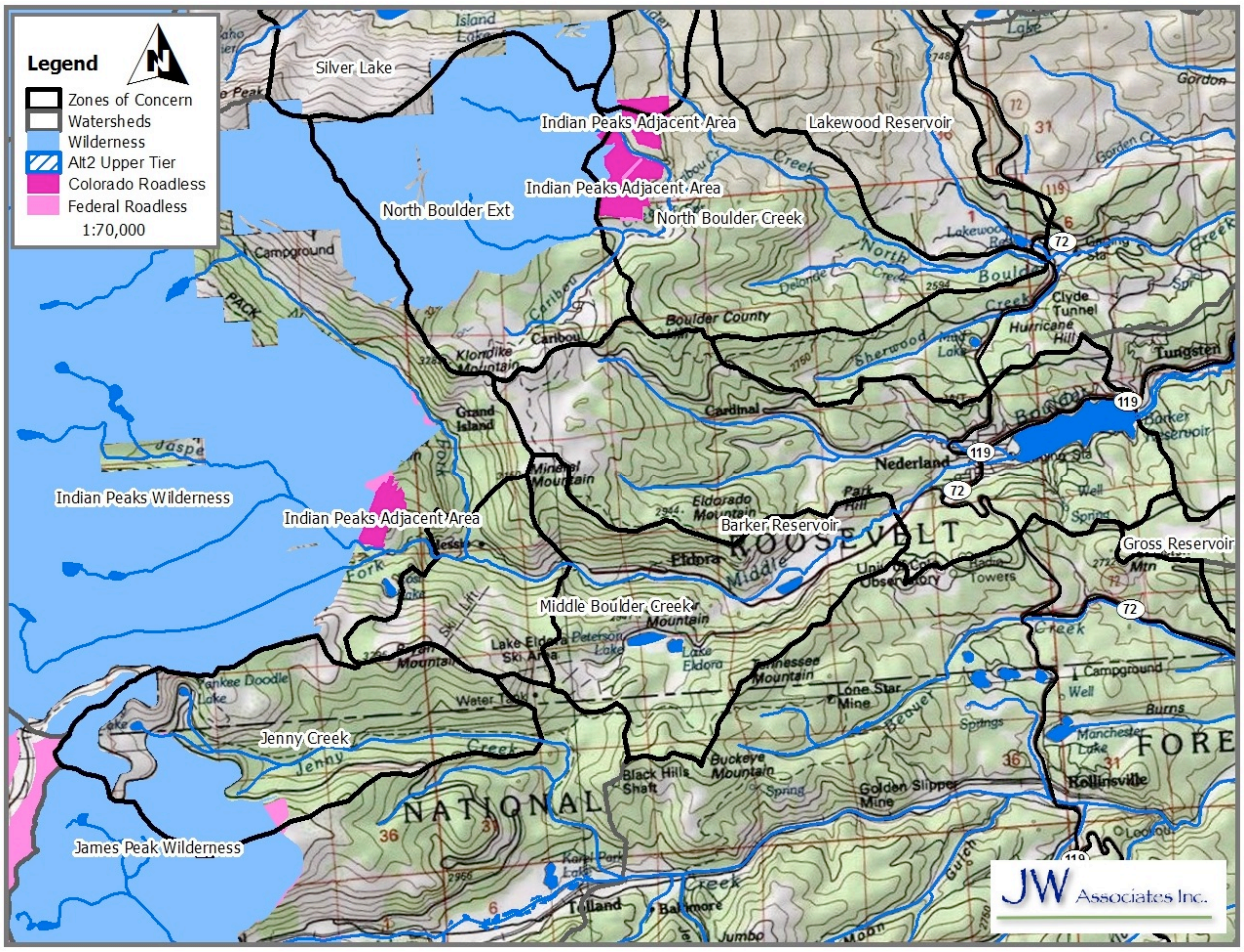


Figure 43. Barker Reservoir ZoC Special Areas

Barker Reservoir ZoC Vegetation

The Barker Reservoir ZoC is dominated by lodgepole pine with some large areas of aspen around Middle Boulder Creek (Figure 44). There are also some areas of grasslands around the reservoir. The Middle Boulder Creek ZoC is a mixture of aspen surrounding the stream channel and lodgepole pine above the aspen. There are some areas of spruce-fir at the highest elevations. The Jenny Creek ZoC transitions from mostly lodgepole pine lower in the ZoC to mostly spruce-fir and finally alpine at the highest elevations (Figure 44).

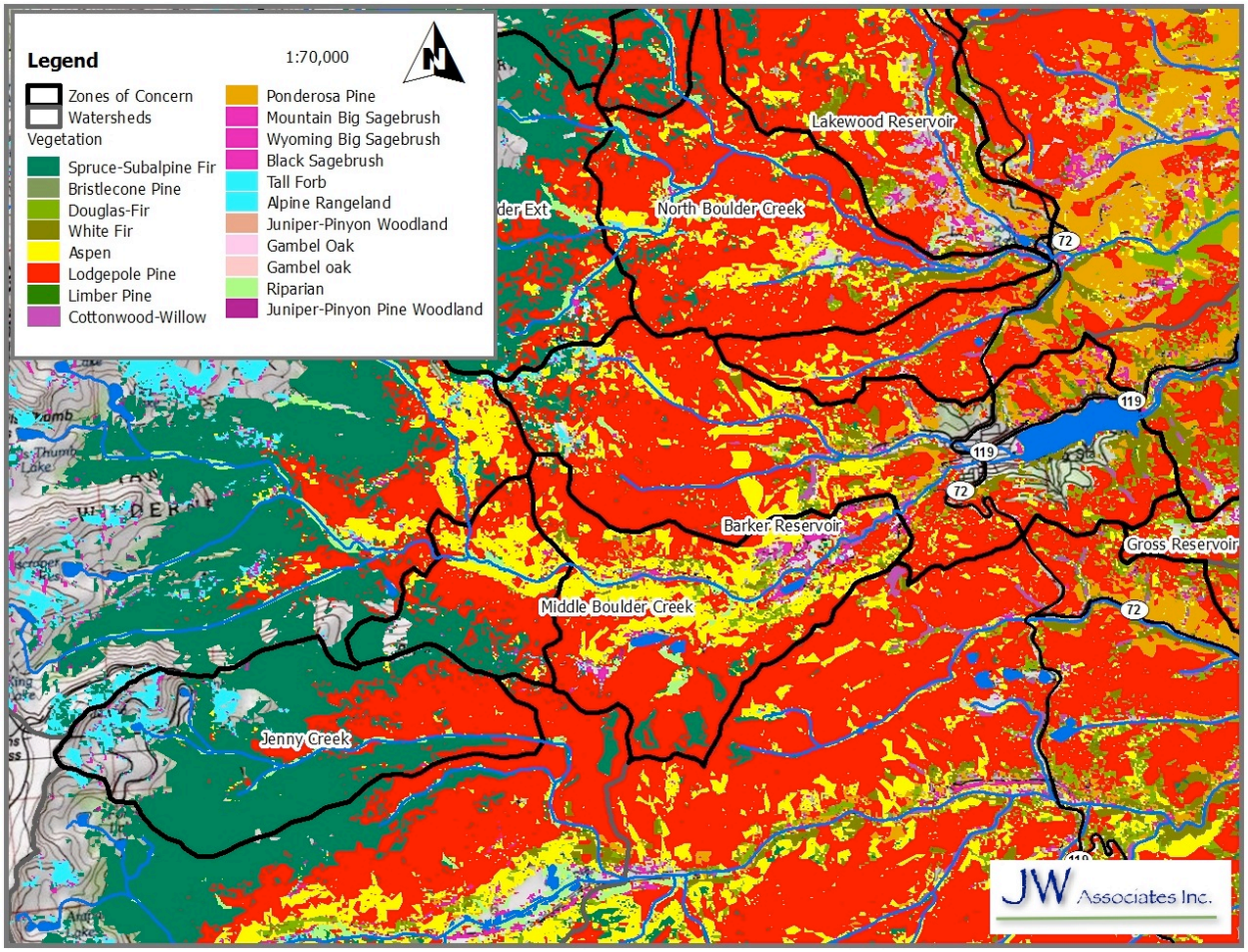


Figure 44. Barker Reservoir ZoC Vegetation

Barker Reservoir ZoC Past Fires

There are no recent past fires that have been mapped within or adjacent to this ZoC (Figure 45).

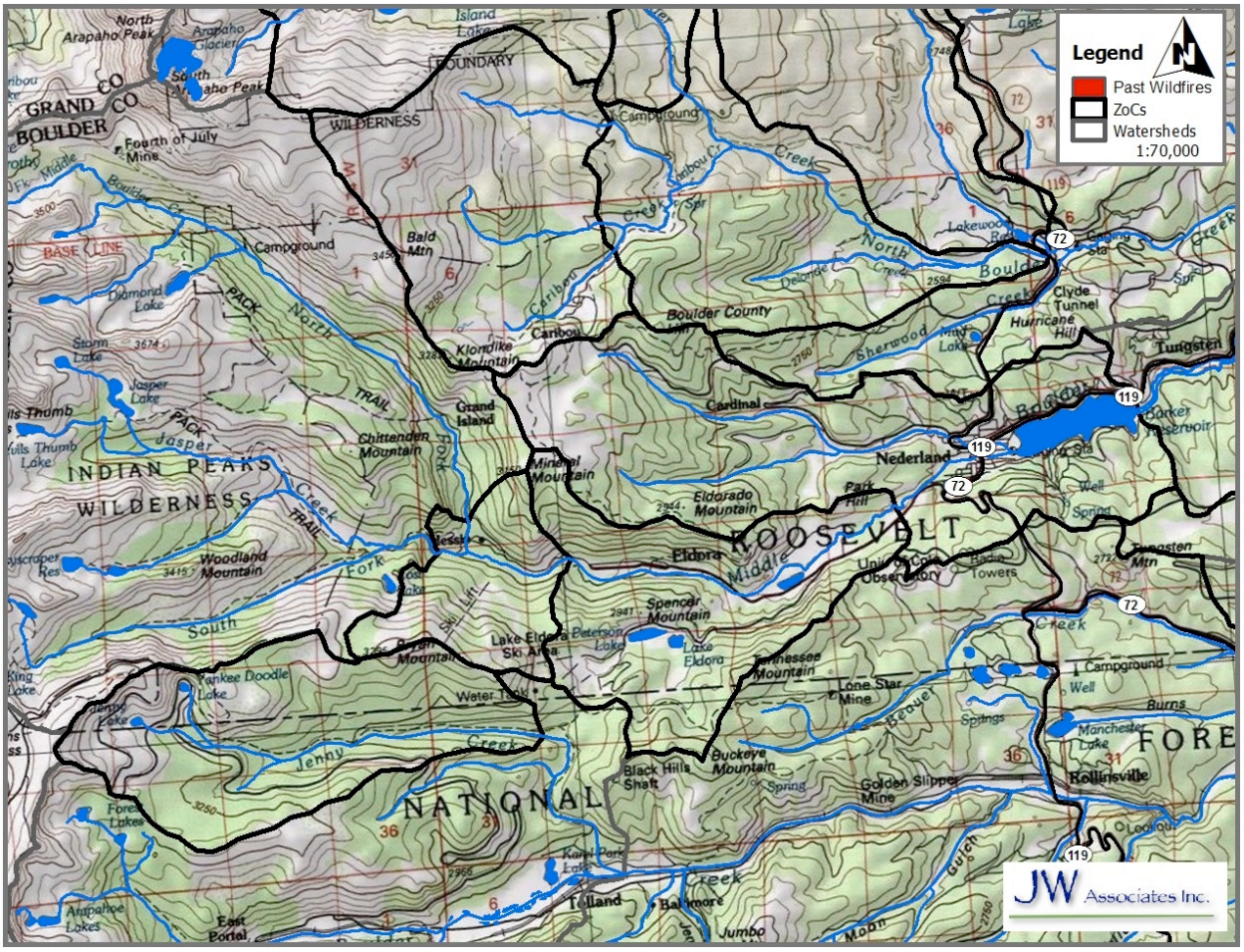


Figure 45. Barker Reservoir ZoC Past Fires

Barker Reservoir ZoC Access

There are many existing roads in the Barker Reservoir ZoC, especially surrounding the reservoir (Figure 46). There are some areas that lack access in the Barker Reservoir ZoC in the northwestern portion, however, there are a number of existing roads throughout this ZoC. The Middle Boulder Creek ZoC also has some access from existing roads, although most of the higher elevations do not have roads. The Jenny Creek ZoC has road access mainly from the Rollins Pass road.

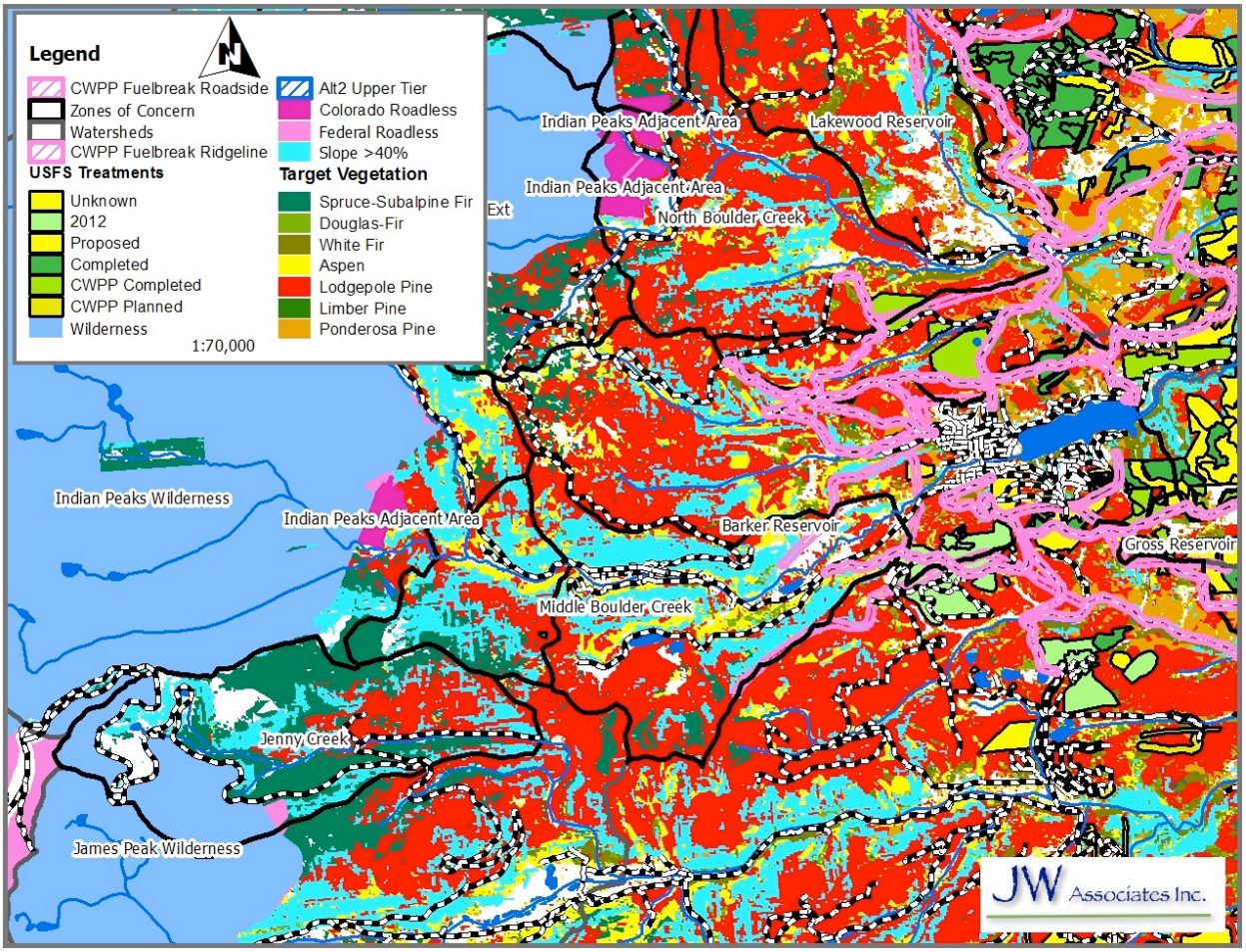


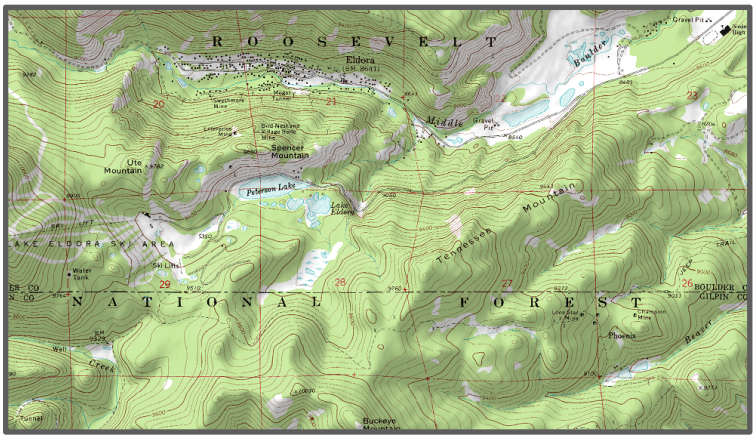
Figure 46. Barker Reservoir ZoC Opportunities

Barker Reservoir ZoC Opportunities

Mechanical treatments in portions of the Jenny Creek ZoC are constrained or limited by wilderness and roadless designations, as well as areas with steep slopes. Access for treatments can occur from the Rollins Pass Road, but that road is rocky and is in need of repair if forest products were to be removed. Equipment could be walked in along this road with little repair if forest products were not removed. Minimal access trails could be developed for access and to treat operable stands distant from the Rollins Pass Road.

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. 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.

Many roadside and ridgeline fuelbreaks and other treatments are proposed and planned in the Barker Reservoir ZoC, as well as to the east, as shown on Figure 46 and listed in the Boulder County CWPP. Review any local CWPPs as well, and work closely with the town of Nederland and the local Fire Protection Districts to implement their plans. Supporting development of comprehensive, community-based defensible space installation can help prevent structure fires from moving into the forest and upslope into the watersheds. Few treatments are currently planned for the western portions of the ZoC.; work with Boulder County and the US Forest Service to develop treatment plans for County and NFS lands.



Steep slopes and limited road access reduce treatment options in a large portion of the Middle Boulder Creek ZoC. Work with the Eldora Ski Area to implement defensible space and other treatments to help prevent fires from moving upslope into the ZoC from developed areas. More favorable slopes and roads and trails provide more favorable treatment opportunities south of Peterson Lake and Tennessee Mountain.

With the large amounts of lodgepole pine in these ZoC, focus should be on developing age diversity through carefully planned and located clearcuts and patchcuts. 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. Maintain current aspen stands through protection, and where necessary, regeneration harvests. Maintain openings in the forest cover and areas with low forest densities.

Button Rock Reservoir ZoC

The Button Rock Reservoir, Longmont Reservoir, North Saint Vrain, Saint Vrain and South Saint Vrain 1 ZoC are adjacent or overlapping and are combined in this discussion (Figure 47). Note that the ZoC are shown here in pink with crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

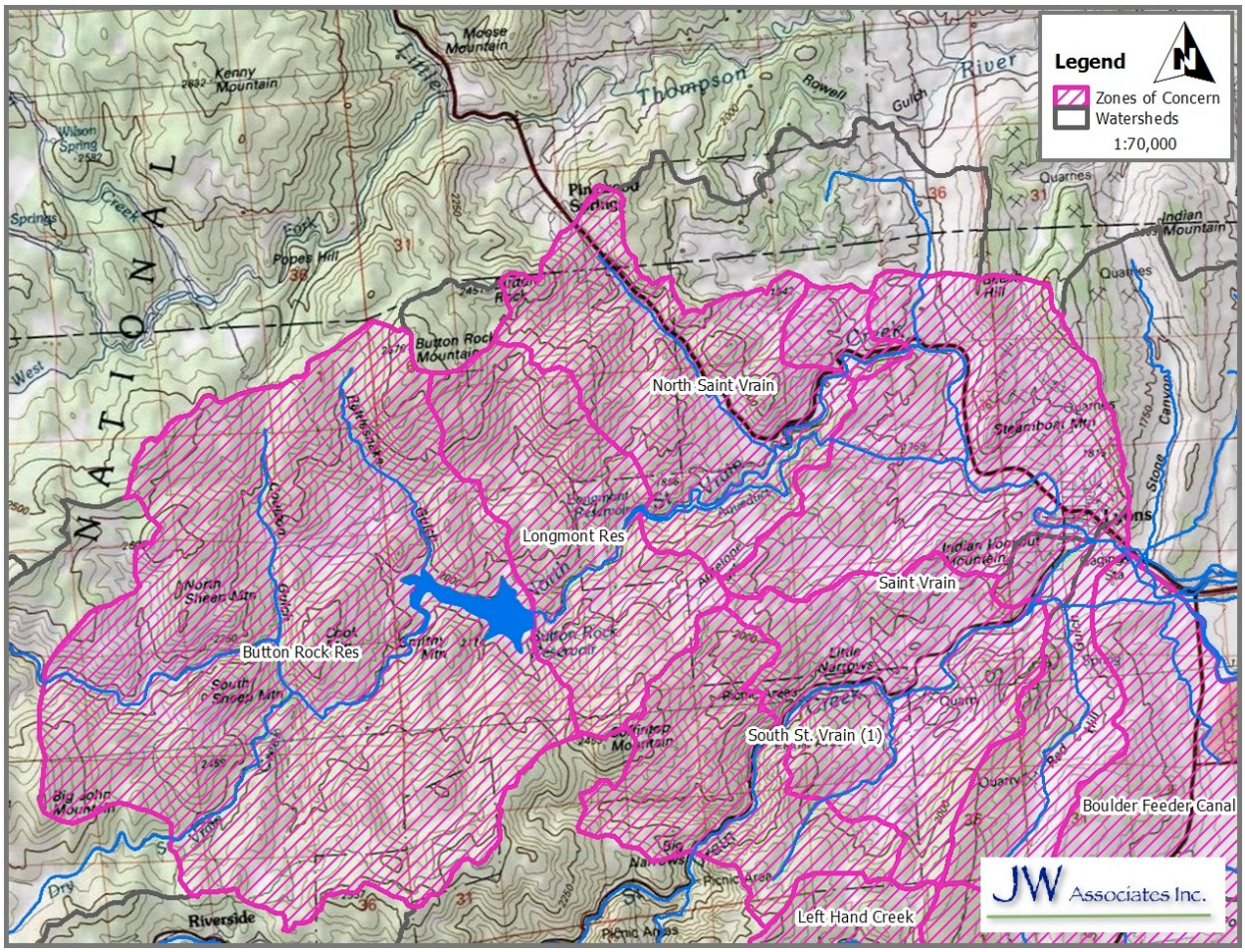


Figure 47. Button Rock Reservoir ZoC Location

Button Rock Reservoir ZoC Ownership

The area around Button Rock Reservoir is owned by the City of Longmont (Figure 48), however most of the Button Rock Reservoir is NFS lands with some Boulder County Open Space and private lands. The Longmont Reservoir ZoC contains City of Greeley lands around North Saint Vrain Creek and Button Rock Reservoir, with NFS lands and some Boulder County Open Space lands higher in the ZoC. The North Saint Vrain ZoC is mostly private lands lower in the ZoC with NFS lands and some Boulder County Open Space lands higher in the ZoC (Figure 48). The Saint Vrain ZoC is mostly private lands lower in the ZoC and mostly Boulder County Open Space lands higher in the ZoC. The South Saint Vrain 1 ZoC is private and Boulder County Open Space lands lower in the ZoC and mostly NFS lands higher in the ZoC. The Heil Valley Ranch Park is located in the southeastern portion of the South Saint Vrain (1) and Saint Vrain ZoC.

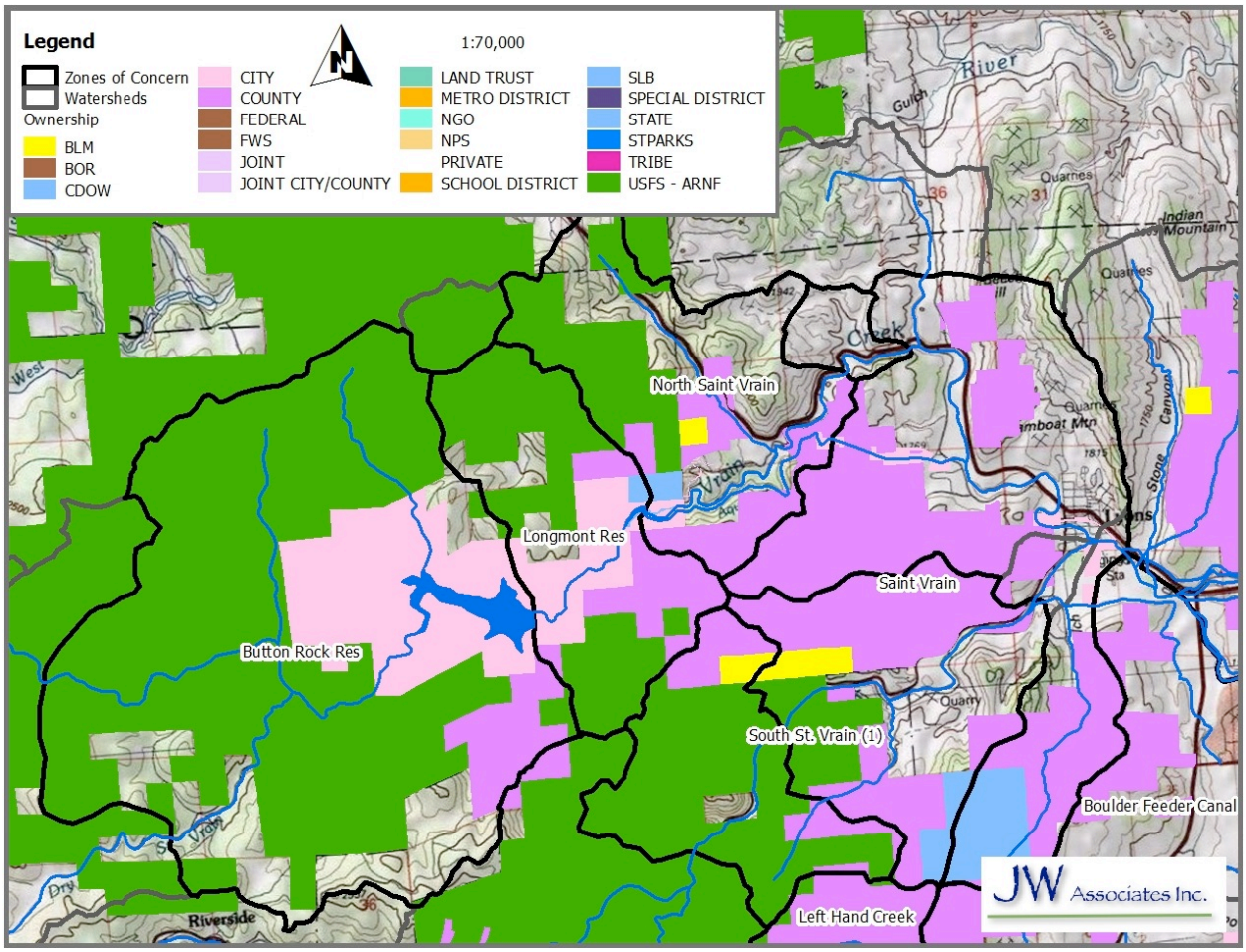


Figure 48. Button Rock Reservoir ZoC Ownership

Button Rock Reservoir ZoC Watershed Priority

The Outlet North Saint Vrain Creek watershed is ranked as Orange (Category 4) overall and for Composite Hazard (Figure 49). It is also ranked as Red (Category 5 - highest) for Wildfire Hazard. The Outlet South Saint Vrain Creek watershed is ranked as Red (Category 5 - highest) overall and for Wildfire Hazard (Figure 49). It is also ranked as Orange (Category 4) for Soil Erodibility and Composite Hazard.

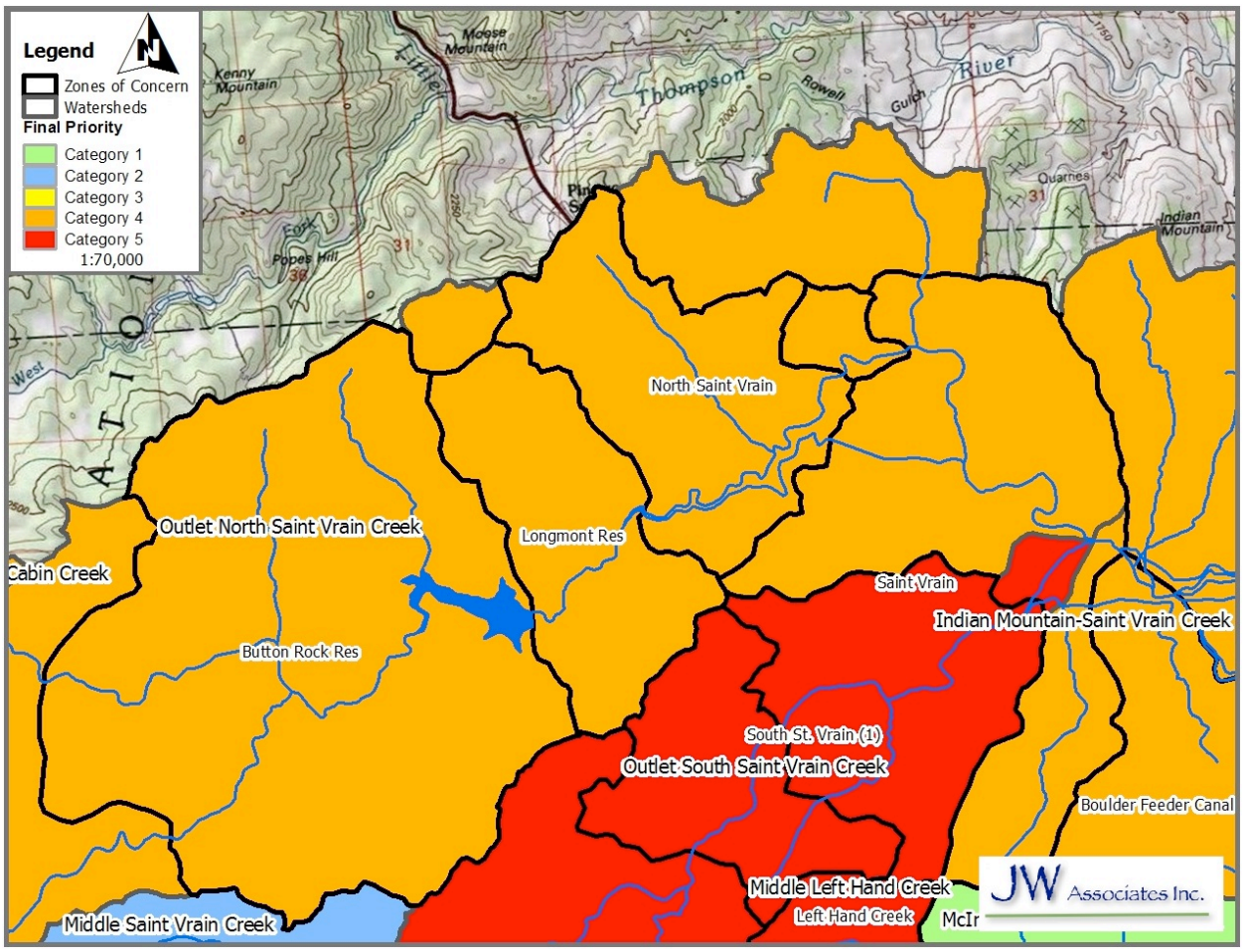


Figure 49. Button Rock Reservoir ZoC Watershed Priority

Button Rock Reservoir ZoC Slopes

The Button Rock ZoC has large areas of steep slopes, surrounding the main stream channels and scattered throughout the slopes between the streams (Figure 50). The Longmont Reservoir ZoC has intermixed steep and shallow slopes. The North Saint Vrain ZoC also has steep slopes surrounding the main stream channels and scattered throughout, similar to the Button Rock ZoC. The Saint Vrain ZoC has large areas of shallow slopes in the northern portion and mixed steep and shallow slopes in the southern portion (Figure 50). The South Saint Vrain (1) ZoC has steep and shallow slopes throughout, with the steep slopes surrounding the main stream channels.

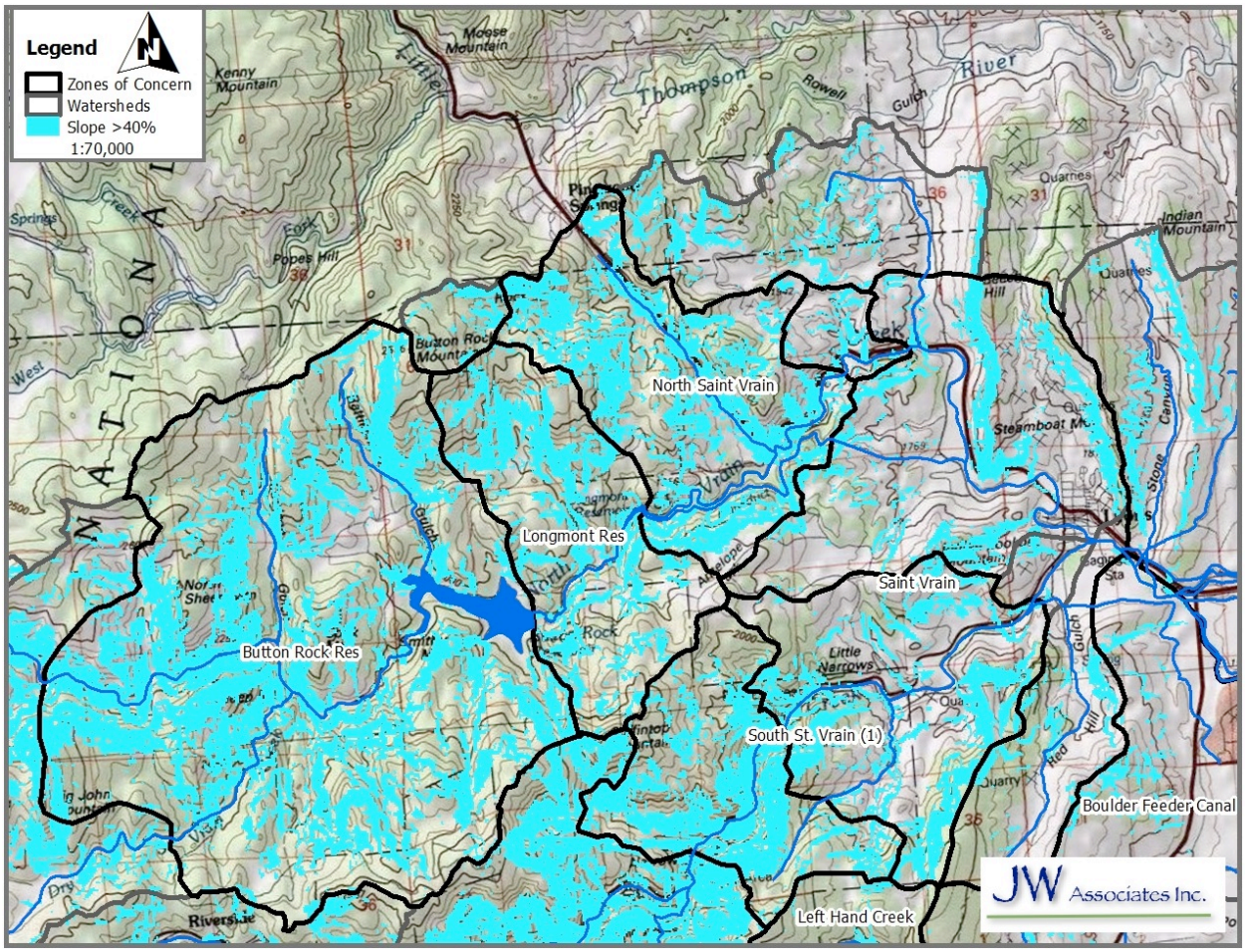


Figure 50. Button Rock Reservoir ZoC Slope

Button Rock Reservoir ZoC Special Management Areas

There are no special management areas in the Saint Vrain and South Saint Vrain (1) ZoC (Figure 47). The North Saint Vrain and Longmont Reservoir ZoC have some areas of the North St. Vrain Roadless Area. The Button Rock ZoC has large areas of the North St. Vrain Roadless Area including some areas designated as Upper Tier (Figure 51).

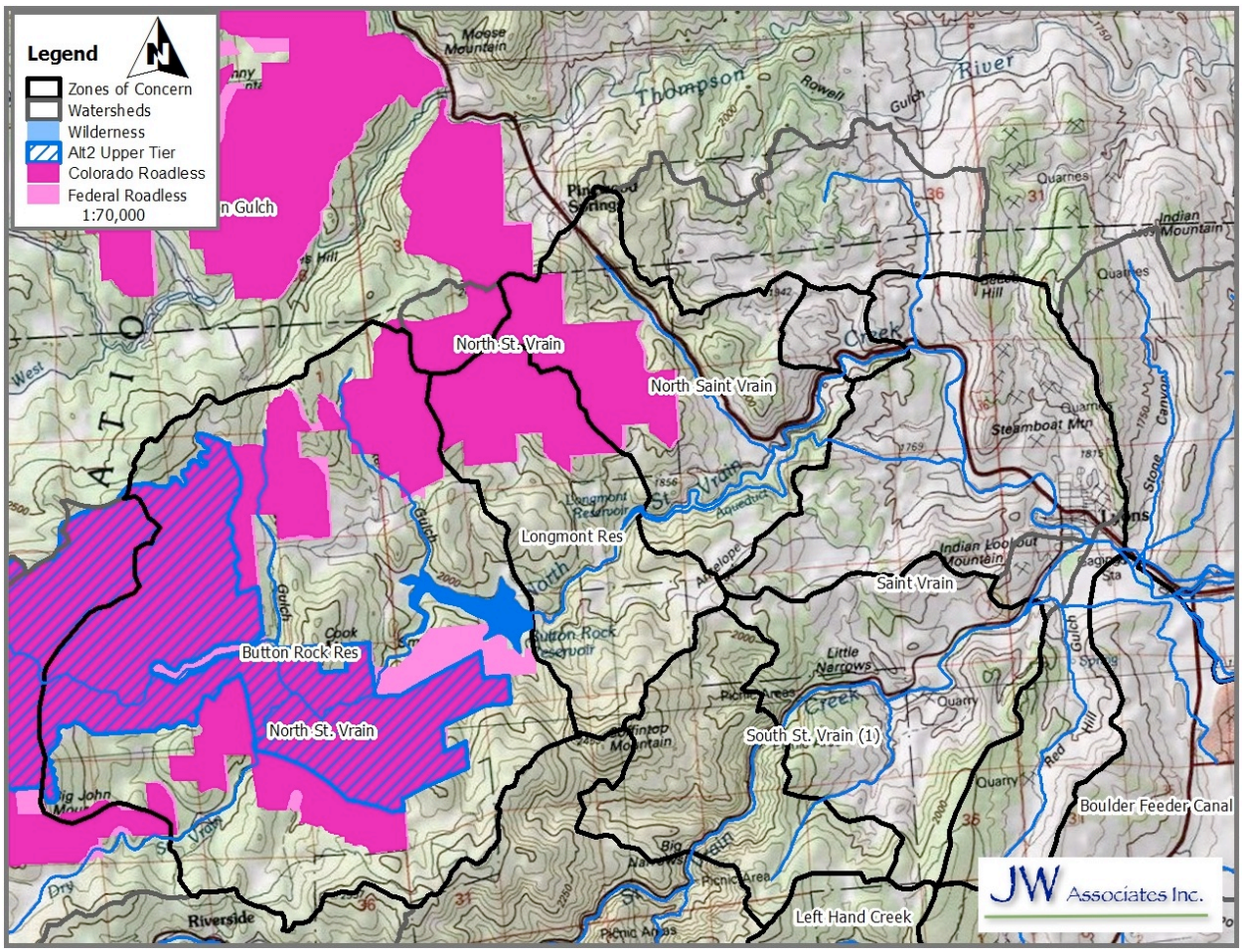


Figure 51. Button Rock Reservoir ZoC Special Areas

Button Rock Reservoir ZoC Vegetation

The Saint Vrain ZoC is a mixture of grasslands and sagebrush at lower elevations and ponderosa pine at higher elevations (Figure 52). The North Saint Vrain and South Saint Vrain (1) ZoC transition from a mixture of ponderosa pine and sagebrush at lower elevations to ponderosa pine on south facing slopes and Douglas-fir on north-facing slopes. The Longmont Reservoir ZoC is mostly ponderosa pine with some areas of Douglas-fir. The Button Rock Reservoir ZoC is dominated by ponderosa pine on south-facing slopes and Douglas-fir on north-facing slopes (Figure 52), with some smaller areas of sagebrush and aspen.

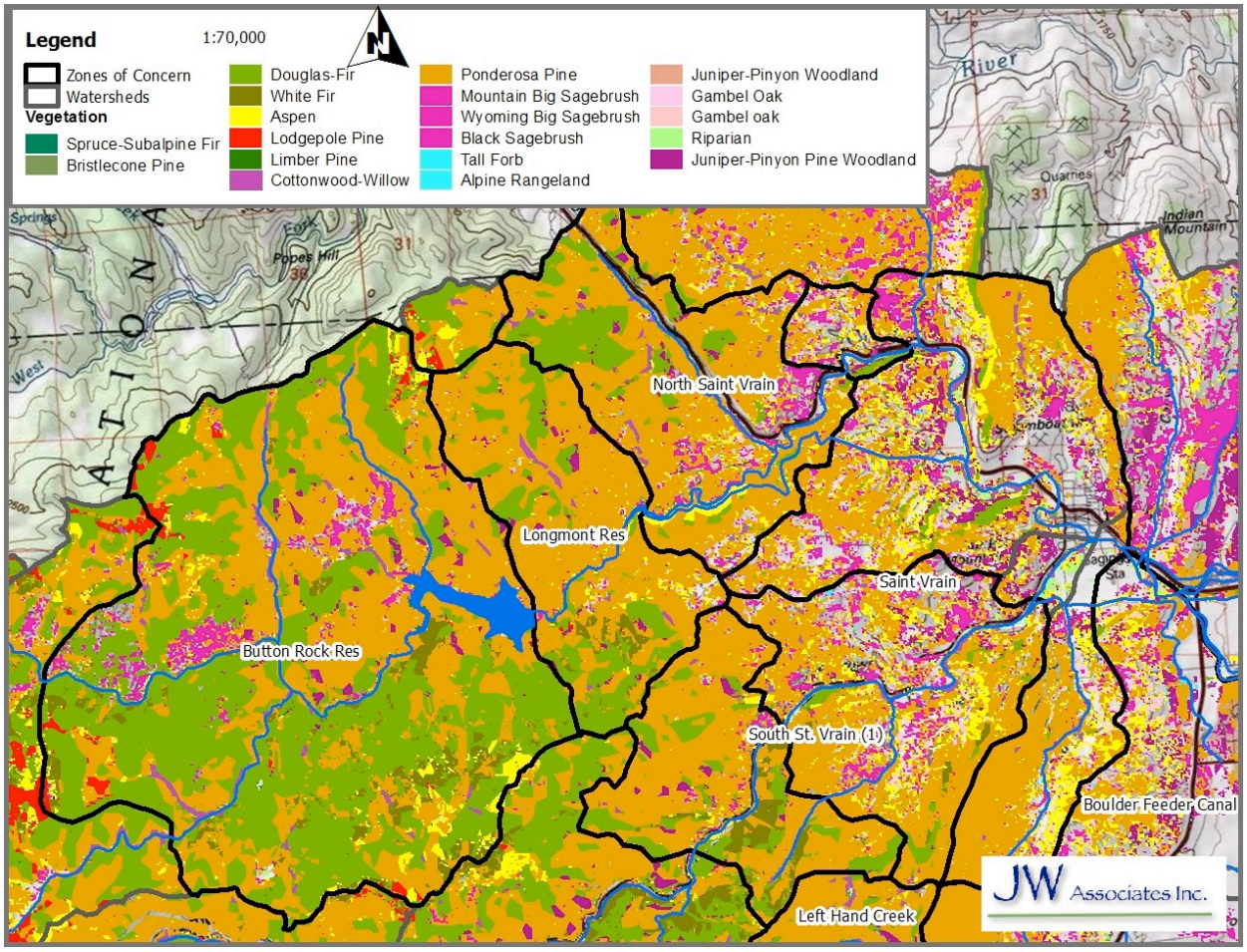


Figure 52. Button Rock Reservoir ZoC Vegetation

Button Rock Reservoir ZoC Past Fires

There are a few small recent past fires that have been mapped within these ZoC (Figure 53). The Button Rock Fire in 2000 and the Longmont Dam Fire of 2011 both burned in the Button Rock ZoC, but were less than 3 acres in size. The Coffintop Fire in 2011 burned in the South Saint Vrain (1) ZoC covering just under 30 acres. It appears that all three of these fires occurred in ponderosa pine. The Stone Canyon Fire in 2011 burned just outside Saint Vrain ZoC.

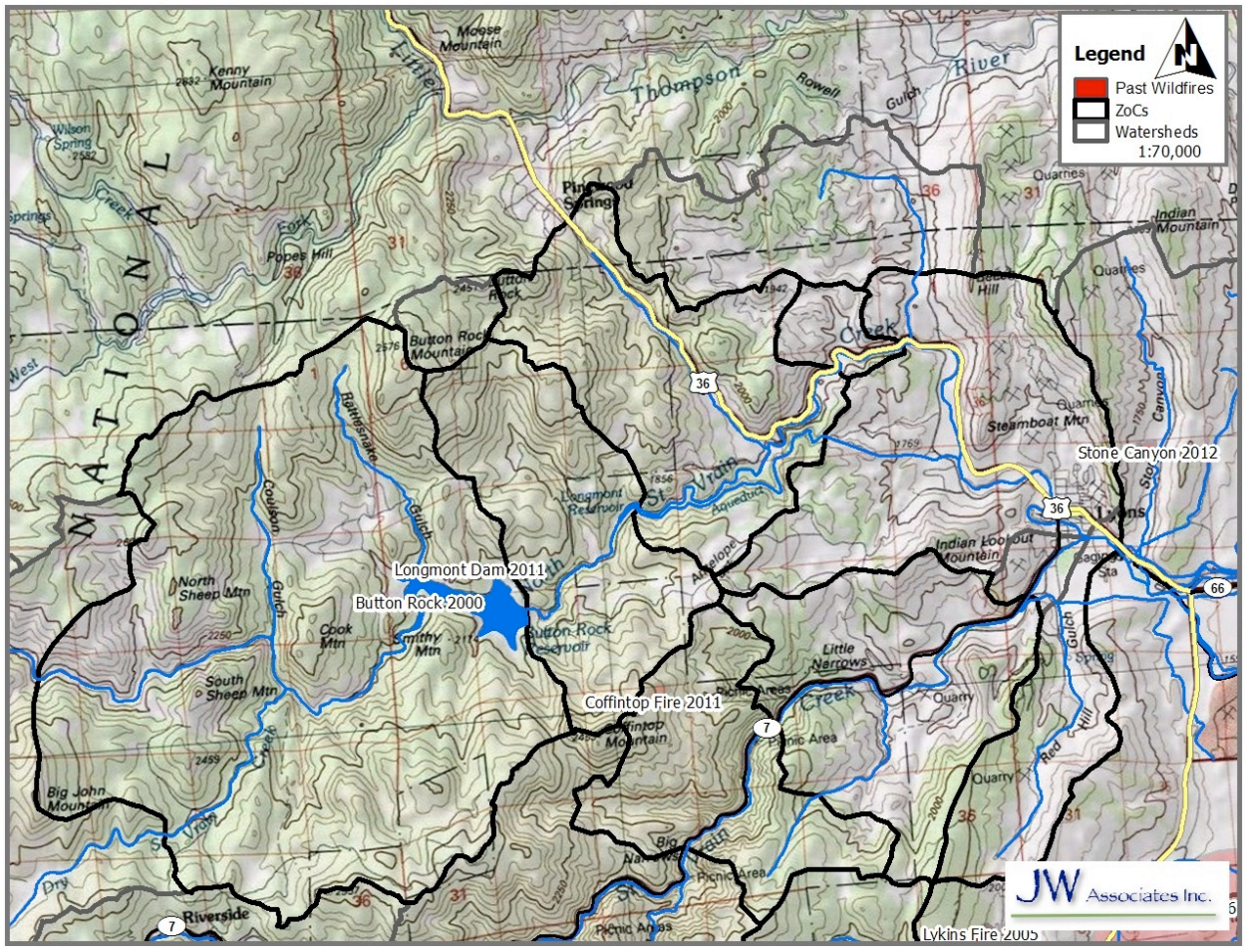


Figure 53. Button Rock Reservoir ZoC Past Fires

Button Rock Reservoir ZoC Access

The Saint Vrain and South Saint Vrain (1) ZoC have some existing roads that provide access (Figure 54). The Longmont Reservoir and Button Rock Reservoir ZoC have limited access.

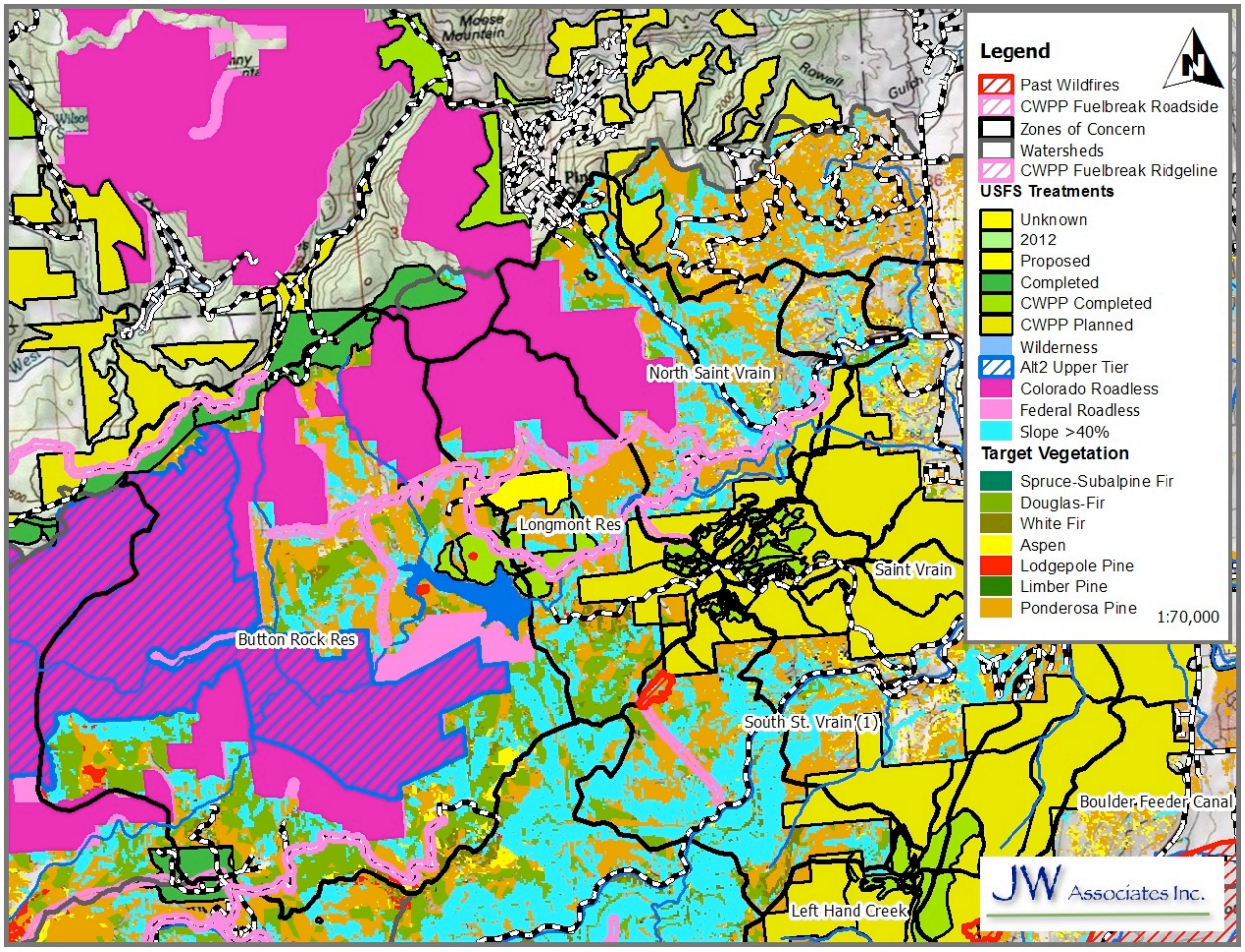
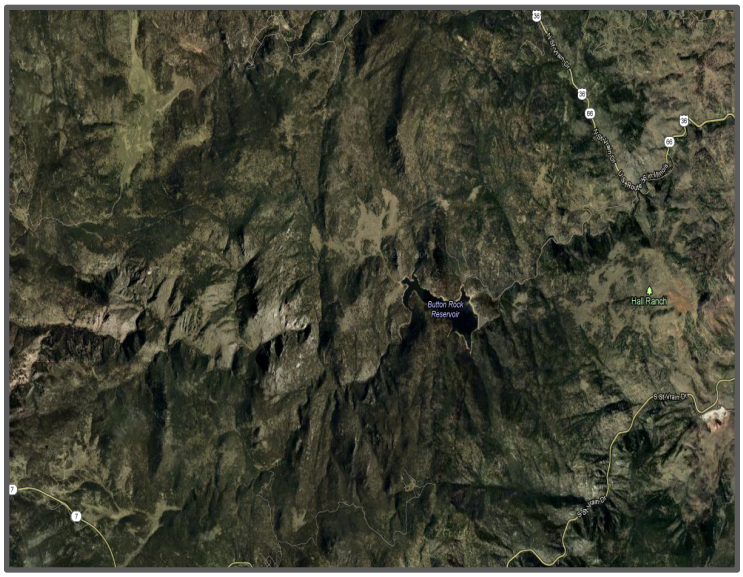


Figure 54. Button Rock Reservoir ZoC Opportunities

Button Rock Reservoir ZoC Opportunities

Treatment opportunities in much of these ZoC are heavily constrained by steep slopes, relatively limited road access and roadless areas. The photo below gives a good sense of the rugged terrain and limited road access. Nevertheless, many treatments are planned in the St. Vrain and South St. Vrain (1) ZoC as shown on Figure 54. The City of Longmont has completed numerous hazardous fuels treatment projects around Button Rock Reservoir. Additional treatments are ongoing and planned. Support all these planned treatments.



Because of the difficult terrain in many areas, much of the planned treatments involve strategic roadside and ridgetop fuelbreaks. These are important to develop and maintain as locations from which defensive suppression actions can be made. The above photo also reveals many areas without trees or with low density forest cover. These are important to maintain, and expand where possible, to allow fires to burn with lower, less-damaging impacts.

Treatments in forested areas should focus on restoration of ponderosa pine and greatly reducing densities of 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. Areas dominated by brush can be periodically mowed or masticated, prescribed burned; or on a limited scale, cut by hand crews. Developing a mosaic of different age classes provides important diversity and keeps a larger percentage of the shrub areas in a younger, more succulent condition.

Left Hand Creek ZoC

The Left Hand Creek, Left Hand Extended, and James Creek ZoC are adjacent or overlapping and are combined in this discussion (Figure 55). The James Creek Extended ZoC is discussed in the Middle Saint Vrain ZoC section above. Note that the ZoC are shown here in pink crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

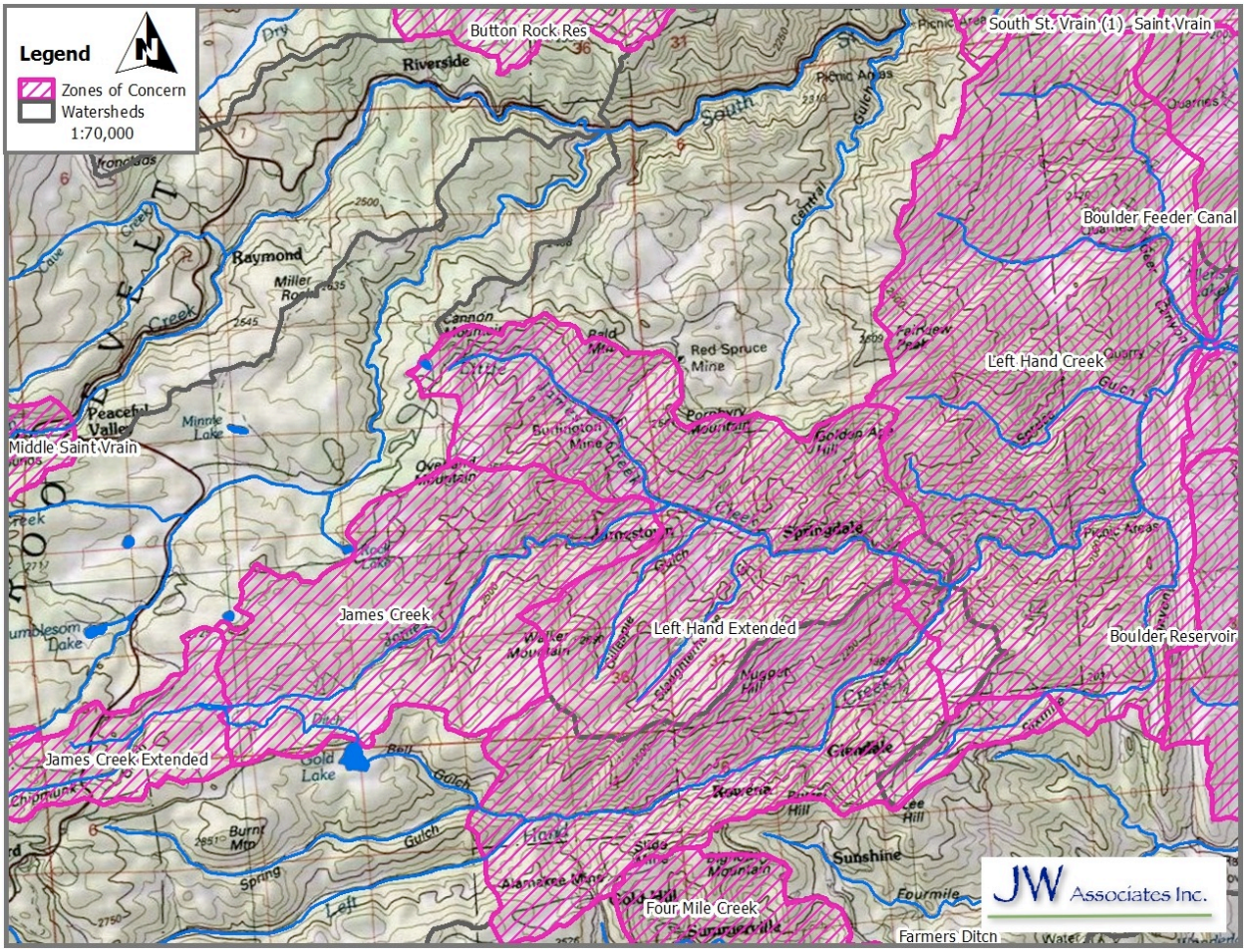


Figure 55. Left Hand Creek ZoC Location

Left Hand Creek Ownership

The Left Hand Creek ZoC has large areas of Boulder County lands in the northern portion (Figure 56) and mixed private and NFS lands in the southern portion. The Left Hand Extended ZoC is mostly NFS lands with mixed ownership of Boulder County, Bureau of Land Management (BLM) and private lands in the southern portions. The James Creek ZoC is divided between NFS and private lands.

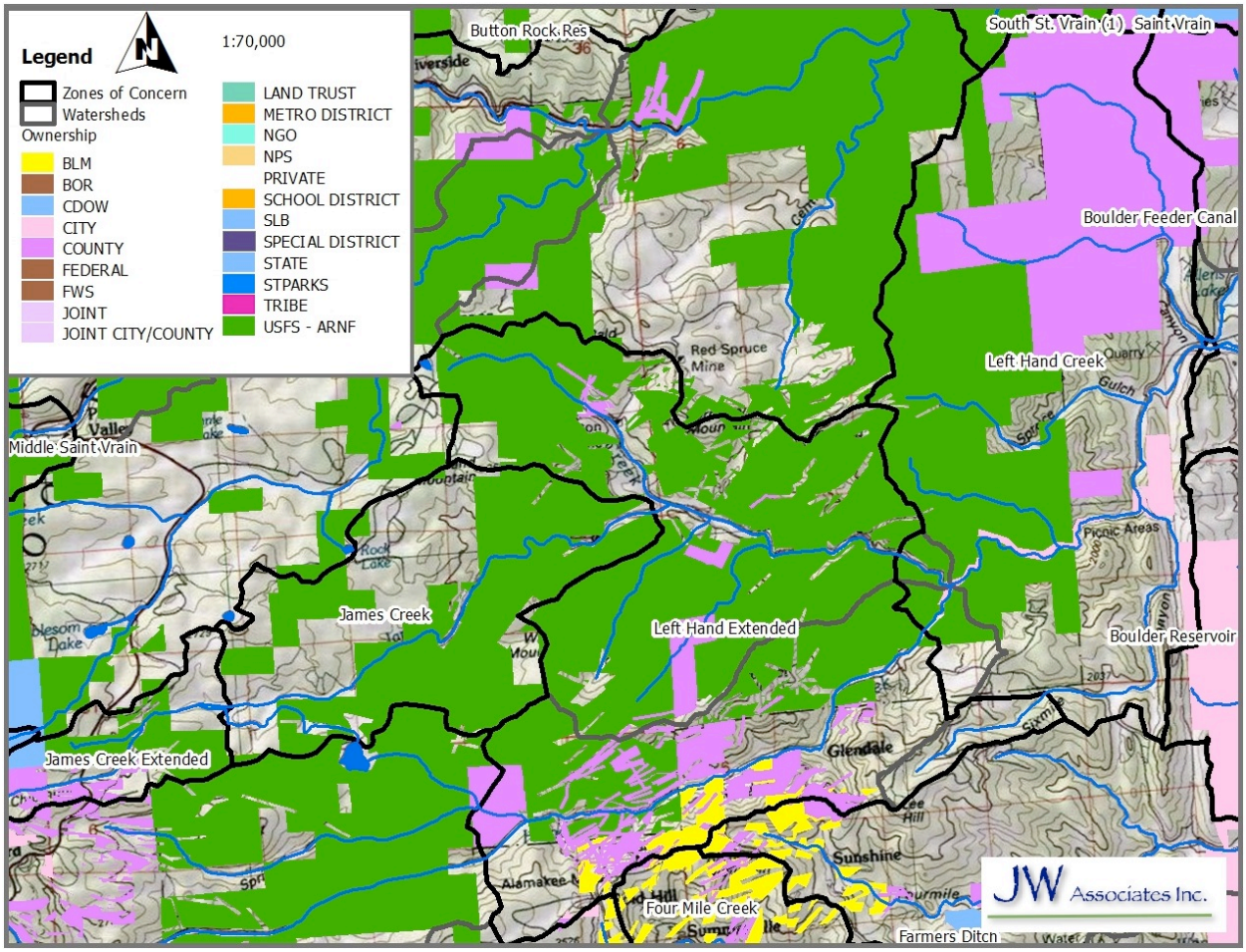


Figure 56. Left Hand Creek ZoC Ownership

Left Hand Creek Watershed Priority

The Middle Left Hand Creek watershed is ranked as Red (Category 5 - highest) overall, and for Soil Erodibility and Composite Hazard (Figure 57). It is also ranked as Orange (Category 4) for Wildfire Hazard. The Upper Left Hand Creek watershed is ranked as Red (Category 5 - highest) overall, and for Flooding/Debris Flow Hazard, Soil Erodibility and Composite Hazard (Figure 57). It is also ranked as Orange (Category 4) for Wildfire Hazard. The James Creek watershed is ranked as Orange (Category 4) overall, Wildfire Hazard, Flooding/Debris Flow Hazard, and Composite Hazard.

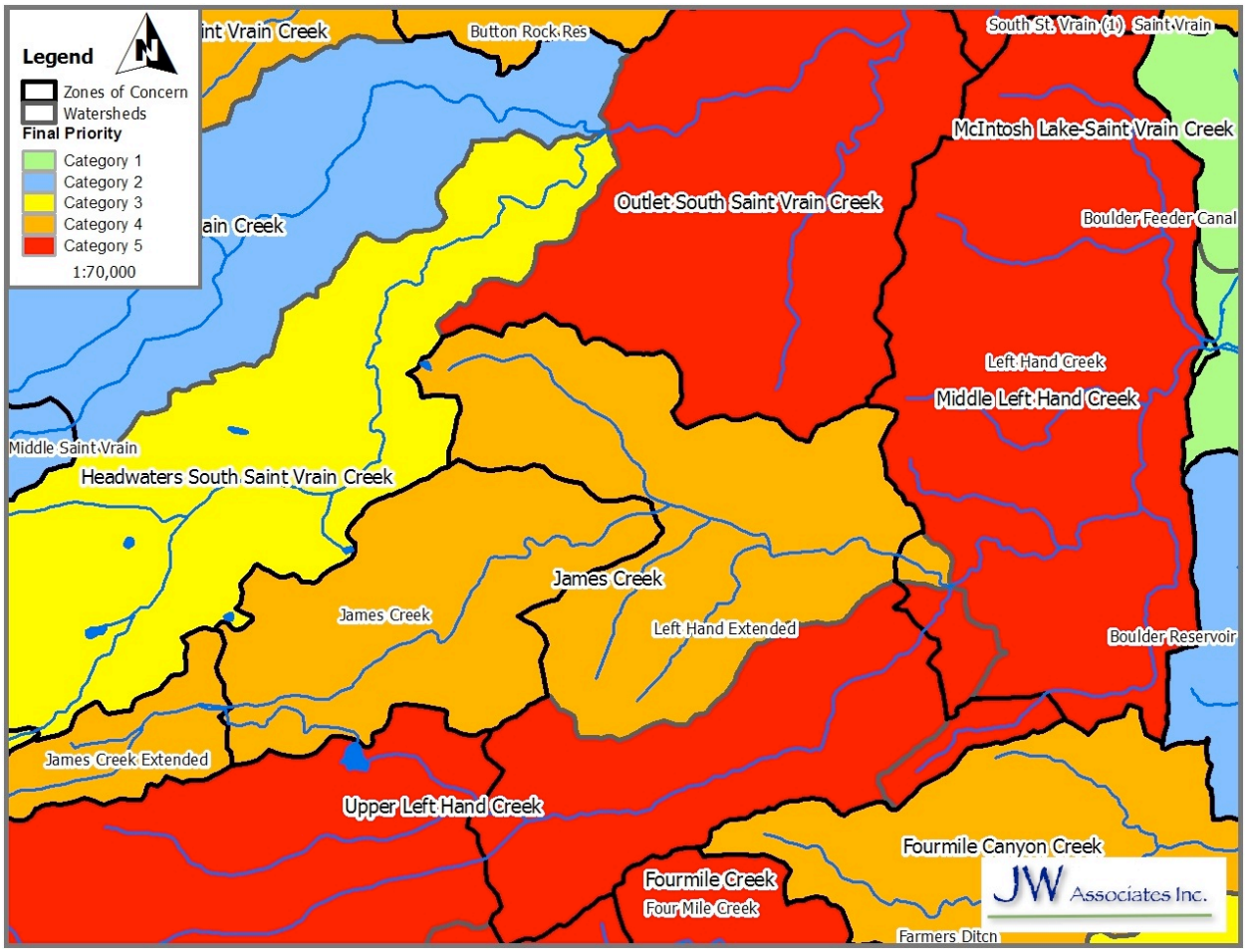


Figure 57. Left Hand Creek ZoC Watershed Priority

Left Hand Creek Slopes

The Left Hand Creek ZoC has some shallow slopes in the northern one-third (Figure 58). The southern portion of this ZoC is generally covered by steep slopes with some small areas of shallower slopes. The Left Hand Extended ZoC is almost entirely steep slopes with some shallow slopes mostly along ridgelines. The James Creek ZoC has steep slopes in the eastern portion but then transitions to shallower slopes in the majority of the ZoC.

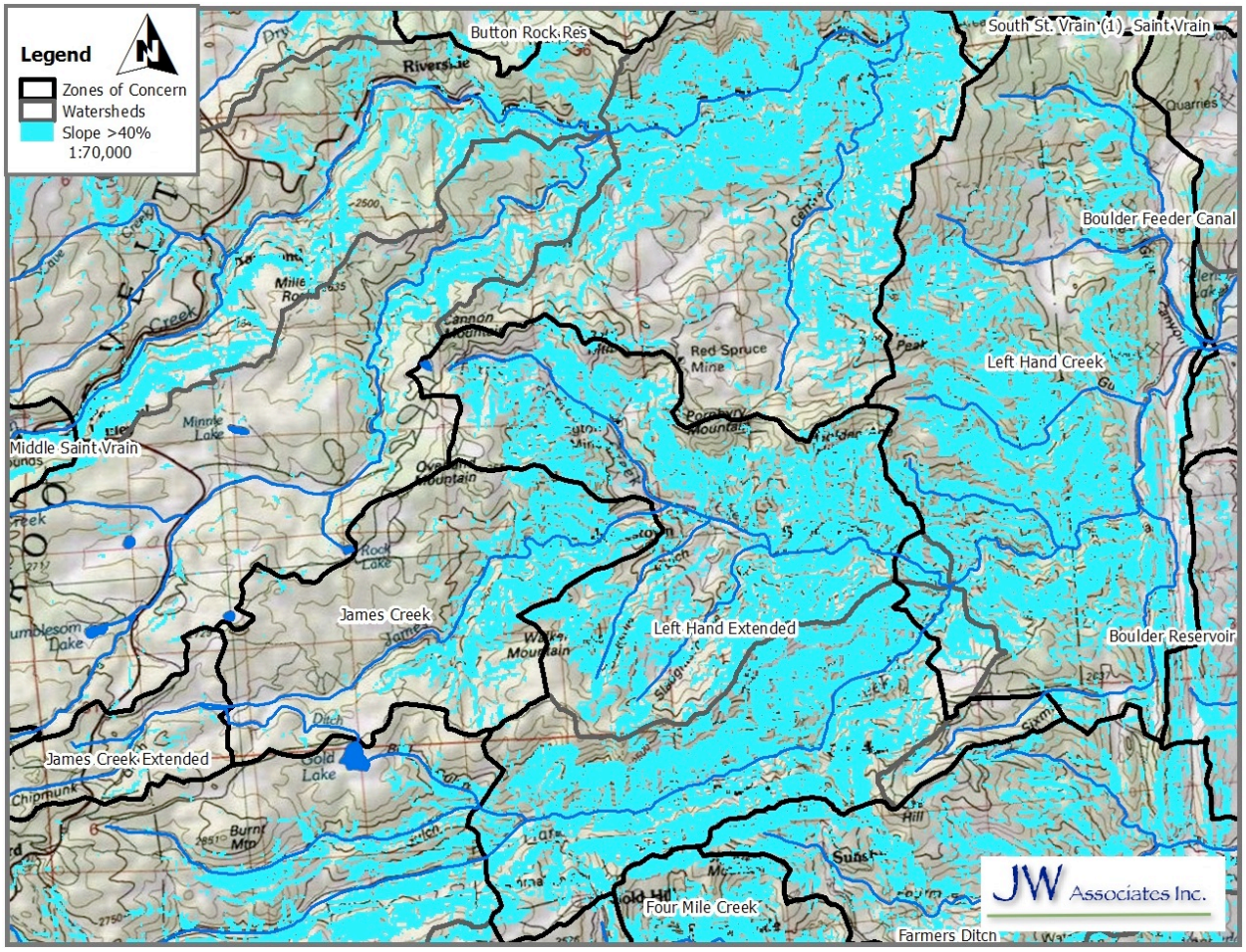


Figure 58. Left Hand Creek ZoC Slope

Left Hand Creek Special Management Areas

There are no special management areas in these ZoC (Figure 59).

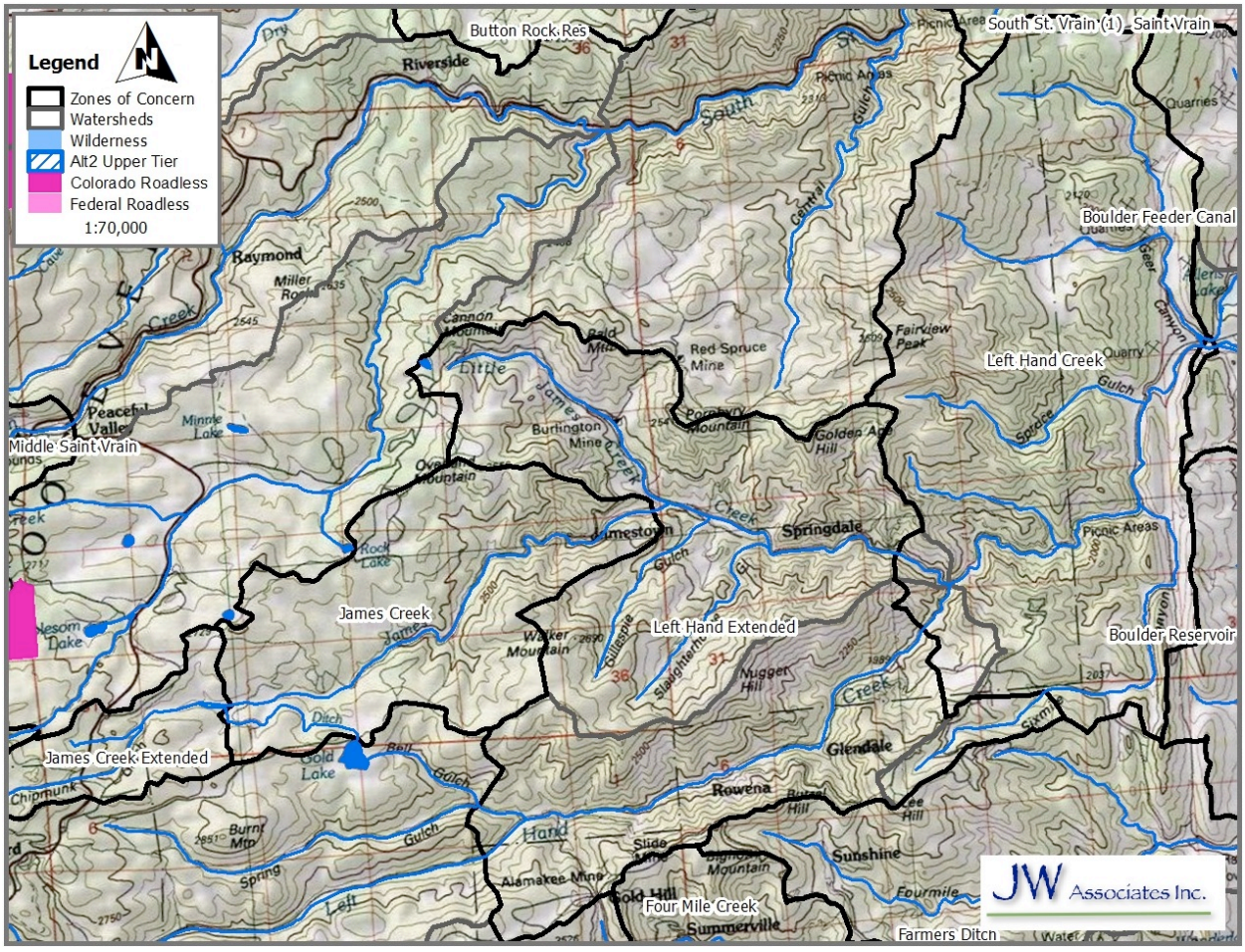


Figure 59. Left Hand Creek ZoC Special Areas

Left Hand Creek Vegetation

The Left Hand Creek ZoC is dominated by ponderosa pine with some areas of Douglas-fir and sagebrush (Figure 60). The Left Hand Extended ZoC is covered with ponderosa pine on south-facing slopes and Douglas-fir on north-facing slopes. The James Creek ZoC transitions from a mixture of ponderosa pine and Douglas-fir at lower elevations to mostly lodgepole pine at higher elevations.

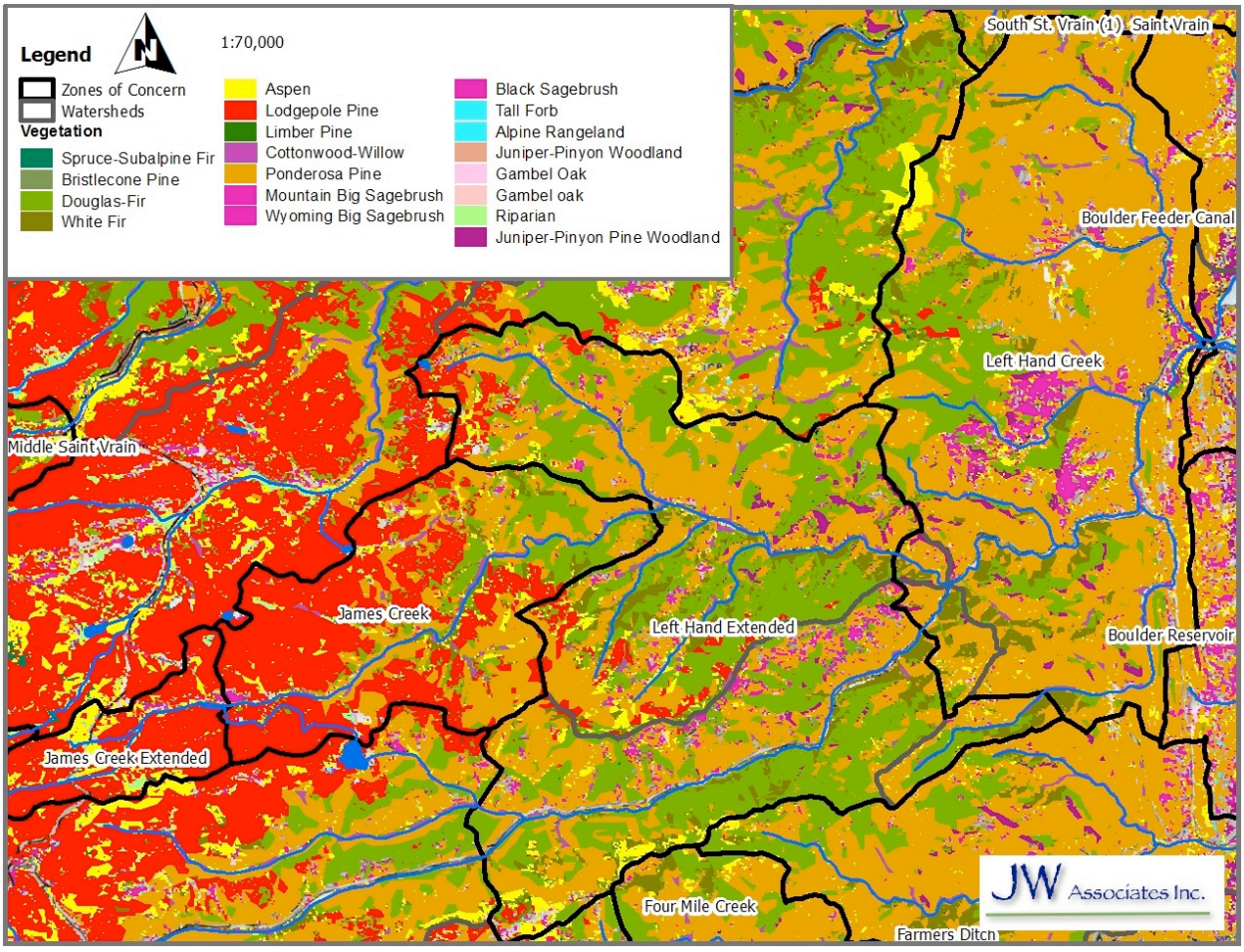


Figure 60. Left Hand Creek ZoC Vegetation

Left Hand Creek Past Fires

There are five overlapping past fires that have been mapped within the Left Hand Creek and Left Hand Extended ZoC (Figure 61). The Left Hand Fire in 1988 burned nearly 3,500 acres. In 2003, the Overland Fire burned more than 2,300 acres just to the north of the Left Hand Fire, with some areas burned in both fires. In 2011, the Left Hand Fire and Maxwell Fire both burned within the area burned 23 years before. These fires burned in the ponderosa pine, Douglas-fir and sagebrush. The Left Hand Fire of 2000 burned just over 20 acres adjacent to the Overland Fire. The Mountain Ridge Fire in 2000, North Foothills Fire in 2005 and Lykins Fire in 2005 all burned just east of the Left Hand Creek ZoC covering relatively small areas. The Old Stage Fire in 2009 covered nearly 3,200 acres and burned a small area of the Left Hand Creek ZoC. In 2010, the Four Mile Fire covered nearly 6,400 acres and burned a small are into the Left Hand Extended ZoC.

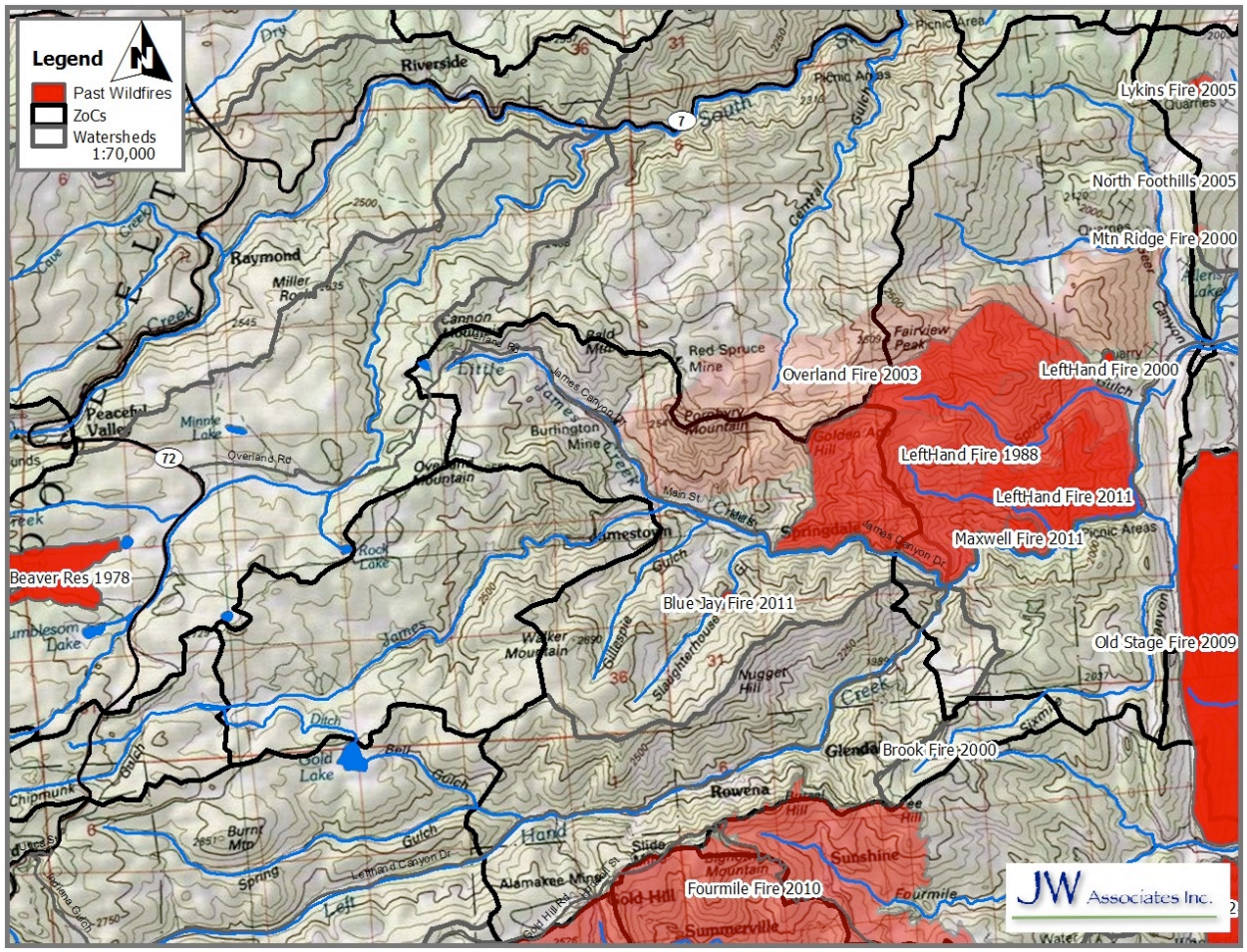


Figure 61. Left Hand Creek ZoC Past Fires

Left Hand Creek Access

Existing roads provide some access to the Left Hand Creek and Left Hand Extended ZoC, although many steep areas do not have existing roads (Figure 62). The James Creek ZoC has good access from existing roads.

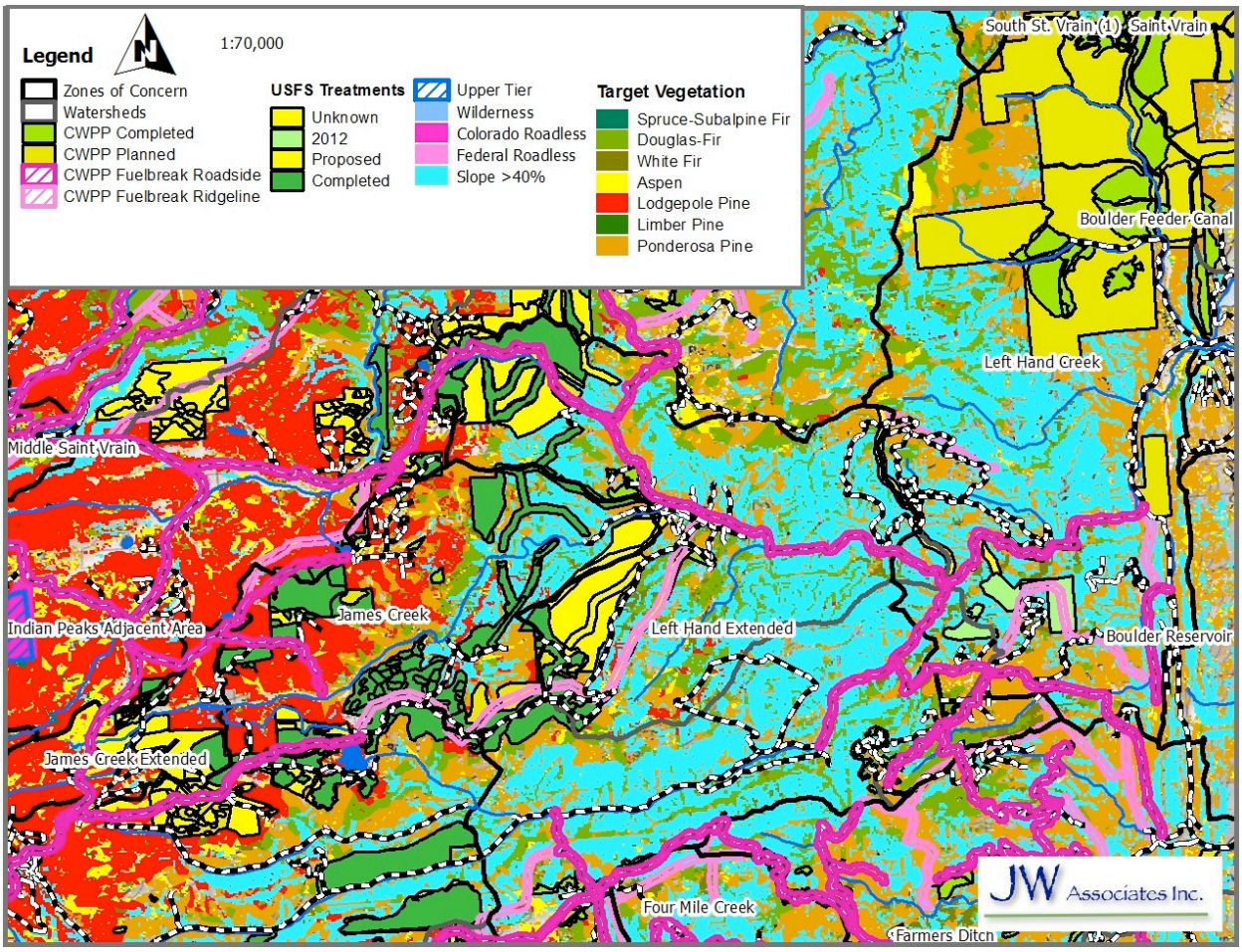


Figure 62. Left Hand Creek ZoC Opportunities

Left Hand Creek Opportunities

Steep slopes greatly limit management opportunities in the Left Hand Creek, the Left Hand Extended, and extreme eastern portions of the James Creek ZoC. As a result, most treatments proposed in the Boulder County CWPP for these areas involve strategic roadside and ridgeline fuelbreaks. These are important to develop and maintain as locations from which defensive suppression actions can be made. The photo to the

right reveals large islands with heavy tree cover, but also many areas without trees or with low density forest cover. These latter areas are important to maintain and expand where possible, to allow fires to burn with lower severity and serve as natural locations to attempt to stop fires that could emerge from the heavily forested areas below.

Where terrain and access improve, many treatments are planned in the James Creek ZoC as shown on Figure 62, and listed in the Boulder County CWPP. Review any local CWPPs and work closely with the town of Jamestown and the local Fire Protection Districts to implement their plans. Supporting development of comprehensive, community-based defensible space installation can help prevent structure fires from moving into the forest and upslope into the watersheds.

At lower elevations, treatments in forested areas should focus on restoration of ponderosa pine and greatly reducing densities of 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. Areas dominated by brush can be periodically mowed or masticated, prescribed burned; or on a limited scale, cut by hand crews. Developing a mosaic of different age classes provides important diversity and keeps a larger percentage of the shrub areas in a younger, more succulent condition.

At higher elevations with the large areas of lodgepole pine, focus should be on developing age diversity through carefully planned and located clearcuts and patchcuts. 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. Maintain current aspen stands through protection, and where necessary, regeneration harvests.

Four Mile Creek ZoC

This section discusses the Four Mile Creek and Farmers Ditch ZoC because they are adjacent and overlapping (Figure 63). Note that the ZoC is shown here in pink crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

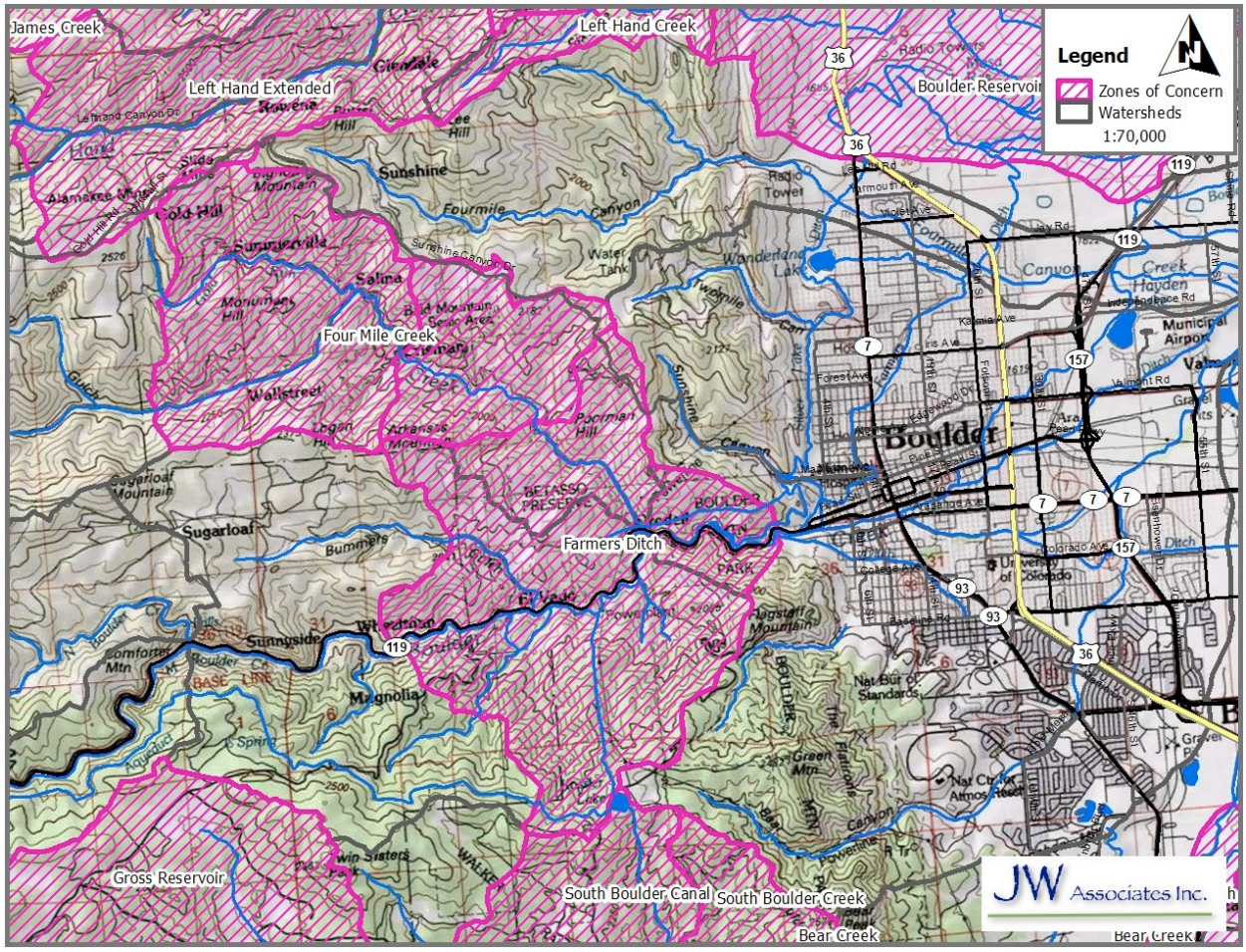


Figure 63. Four Mile Creek ZoC Location

Four Mile Creek Ownership

The Four Mile Creek ZoC ownership is divided between private, BLM and Boulder County lands (Figure 64). The Farmers Ditch ZoC is divided into City of Boulder, Boulder County, private and NFS lands.

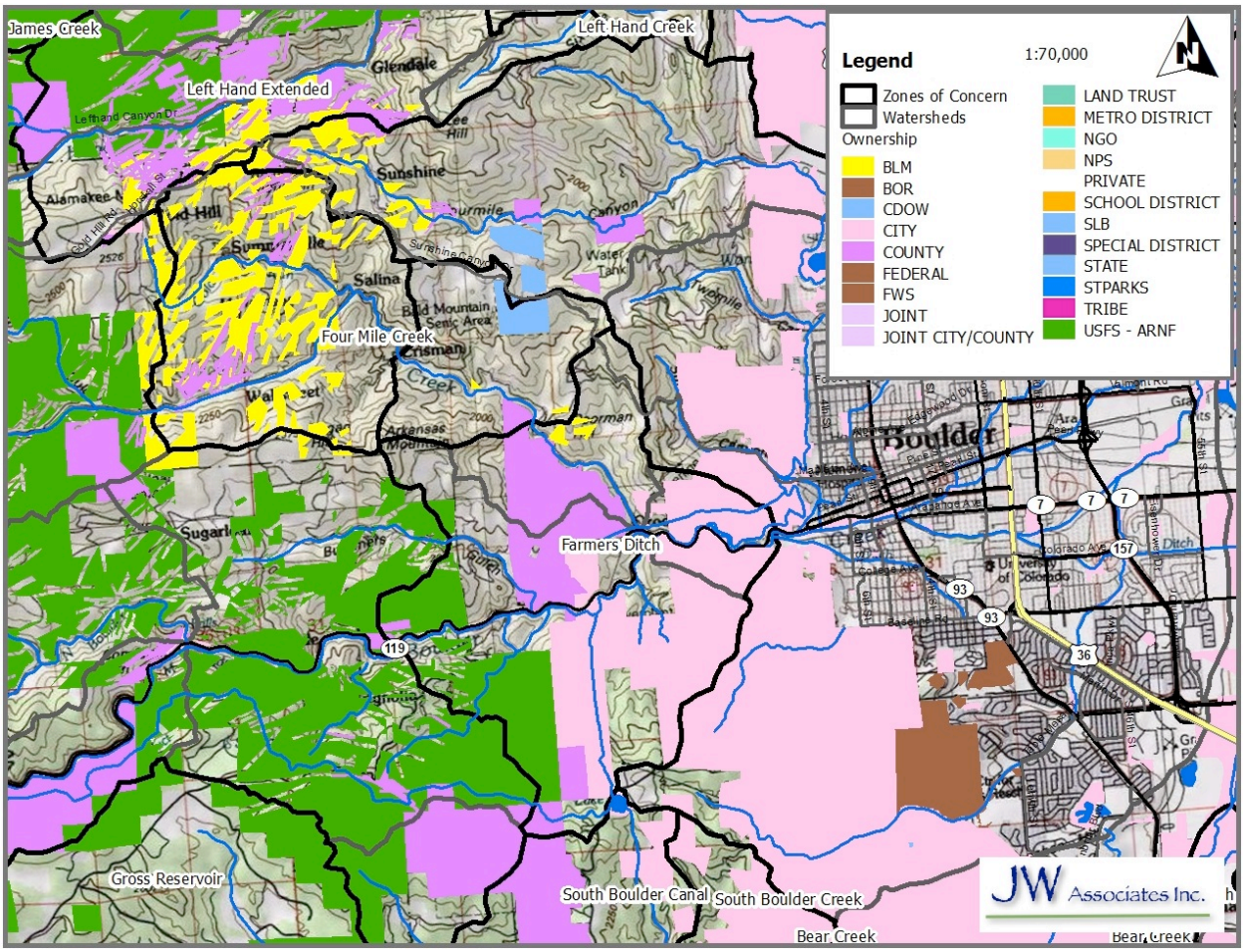


Figure 64. Four Mile Creek ZoC Ownership

Four Mile Creek Watershed Priority

The Fourmile Creek watershed (Figure 59) is ranked Red overall (Category 5 - highest) and for Flooding/Debris Flow Hazard and Composite Hazard. It also ranks as Orange (Category 4) for Wildfire Hazard and Soil Erodibility. The Boulder Creek Canyon watershed (Figure 65) is ranked Red overall (Category 5 - highest) and for Wildfire Hazard, Soil Erodibility, and Composite Hazard. It also ranks as Orange (Category 4) for Flooding/ Debris Flow Hazard.

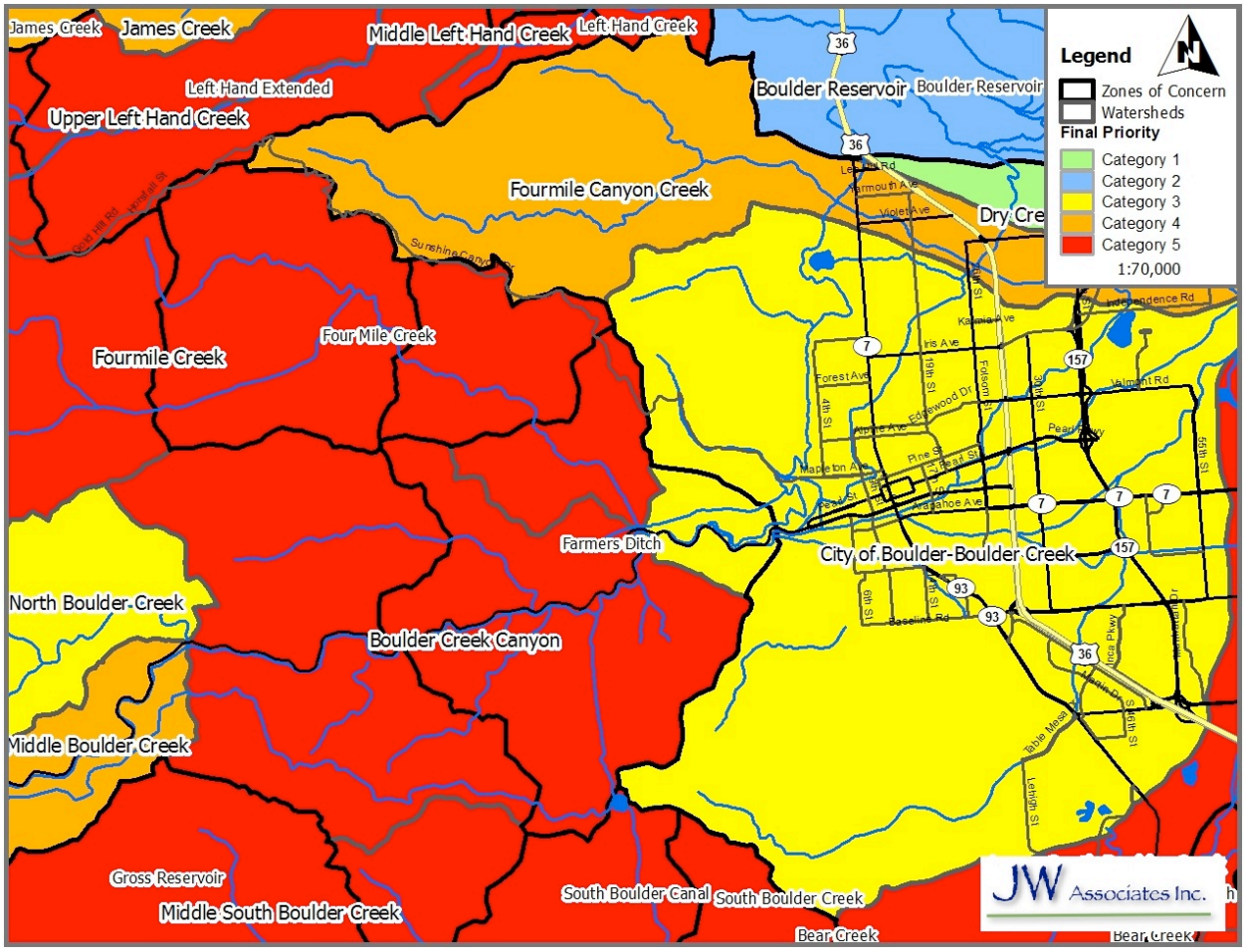


Figure 65. Four Mile Creek ZoC Watershed Priority

Four Mile Creek Slopes

These two ZoC are characterized by very steep slopes throughout (Figure 66). There are only a few areas within each ZoC that have slopes less than 40 percent.

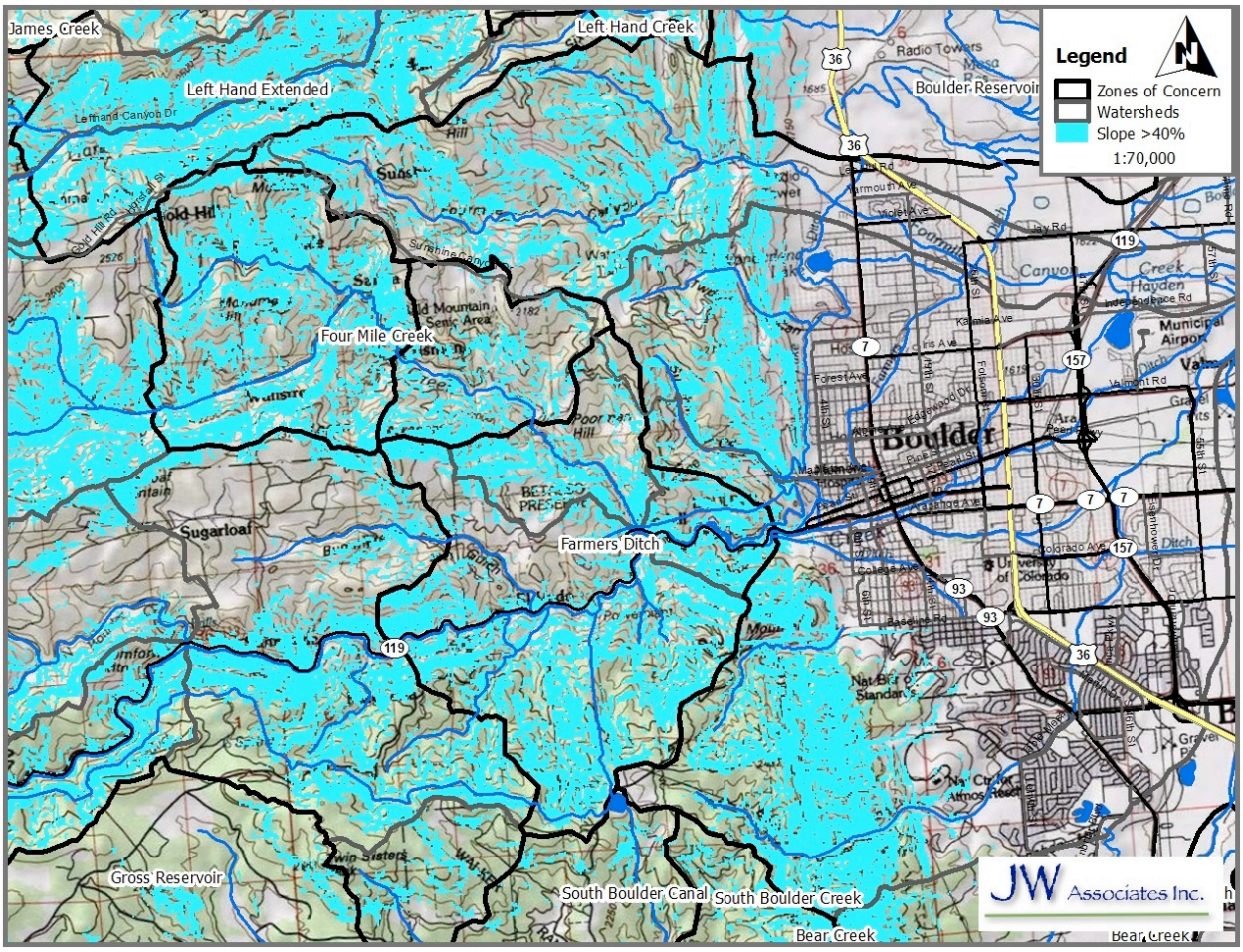


Figure 66. Four Mile Creek ZoC Slope

Four Mile Creek Special Management Areas

There are no special management areas in these ZoC (Figure 67).

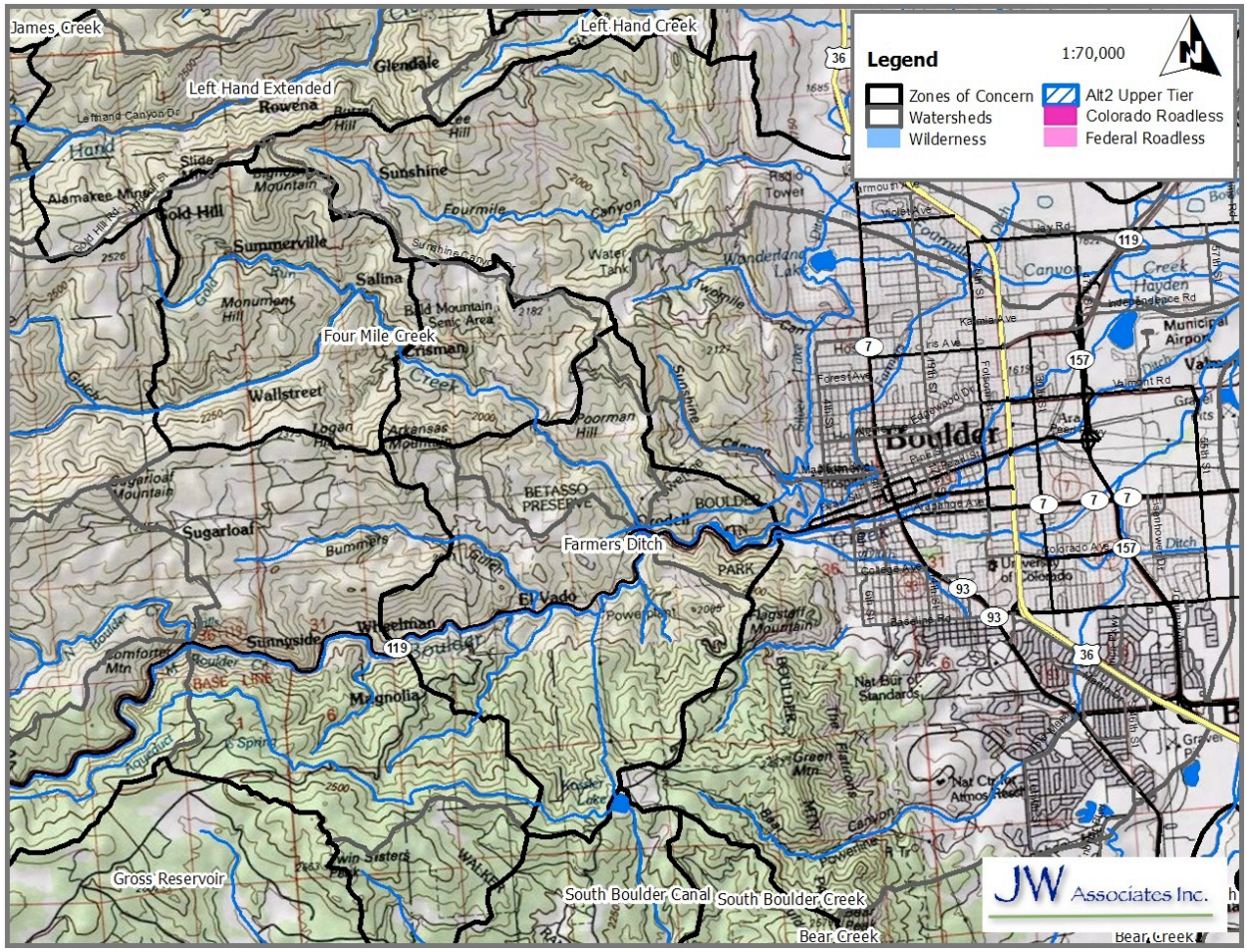


Figure 67. Four Mile Creek ZoC Special Areas

Four Mile Creek Vegetation

The vegetation in the Farmers Ditch and Four Mile Creek ZoC are very similar (Figure 68). These two ZoC are mostly ponderosa pine with some areas of Douglas-fir and Douglas-fir mixed with ponderosa pine.

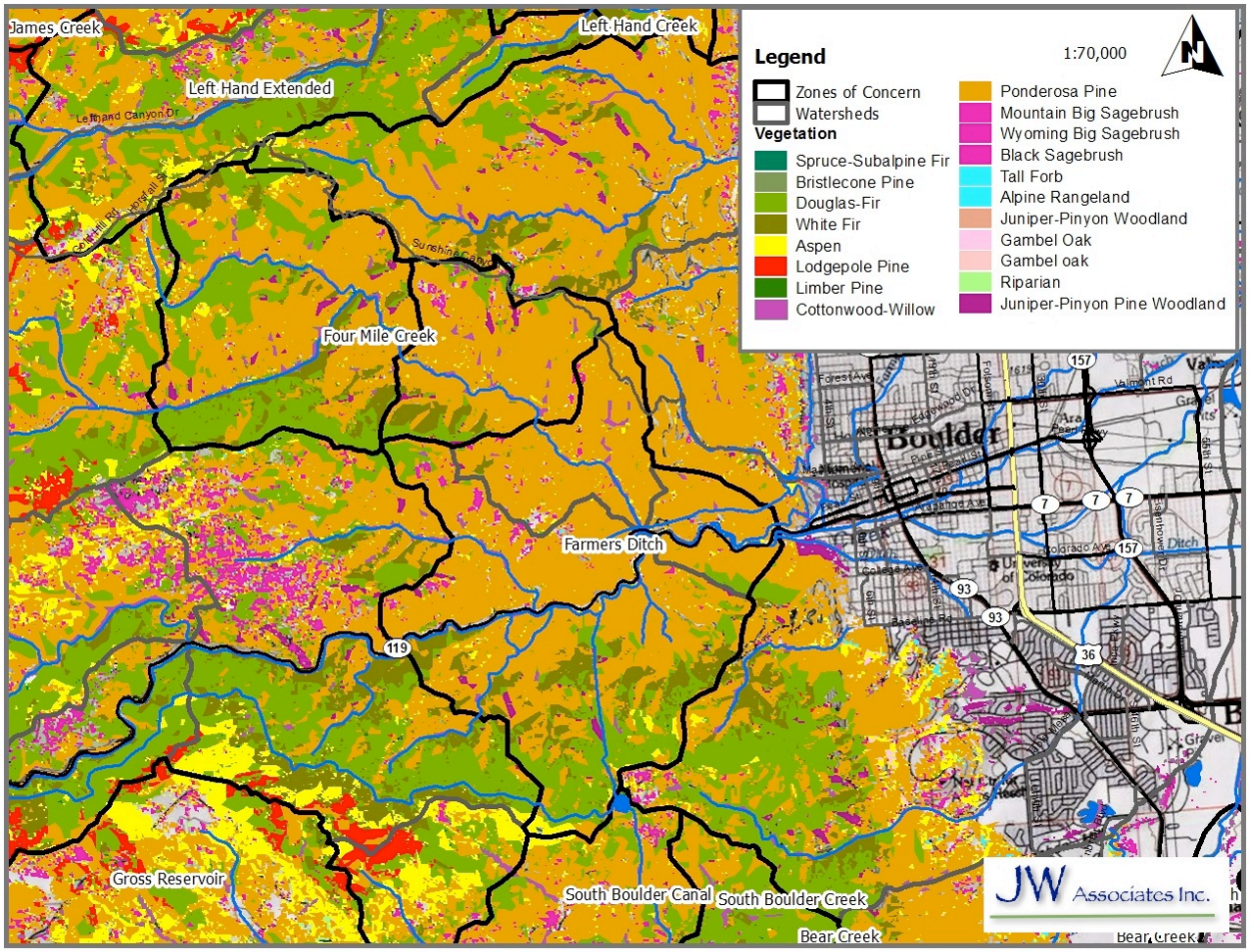


Figure 68. Four Mile Creek ZoC Vegetation

Four Mile Creek Past Fires

The biggest fire that has been mapped within these ZoC is the Four Mile Fire that burned just under 6,400 acres in 2010 (Figure 69) covering the majority of the Four Mile Creek ZoC. That fire burned mostly in the ponderosa pine and Douglas-fir. The Four Mile Fire also burn a portion of the Farmers Ditch ZoC. The Sunshine Canyon fire of 2006 and the Poorman Fire of 2000 burned a small number of acres in the Farmers Ditch ZoC. The Black Tiger Fire in 1989 burned nearly 1,900 acres just outside of the Four Mile Creek ZoC and covering a small portion of the Farmers Ditch ZoC.

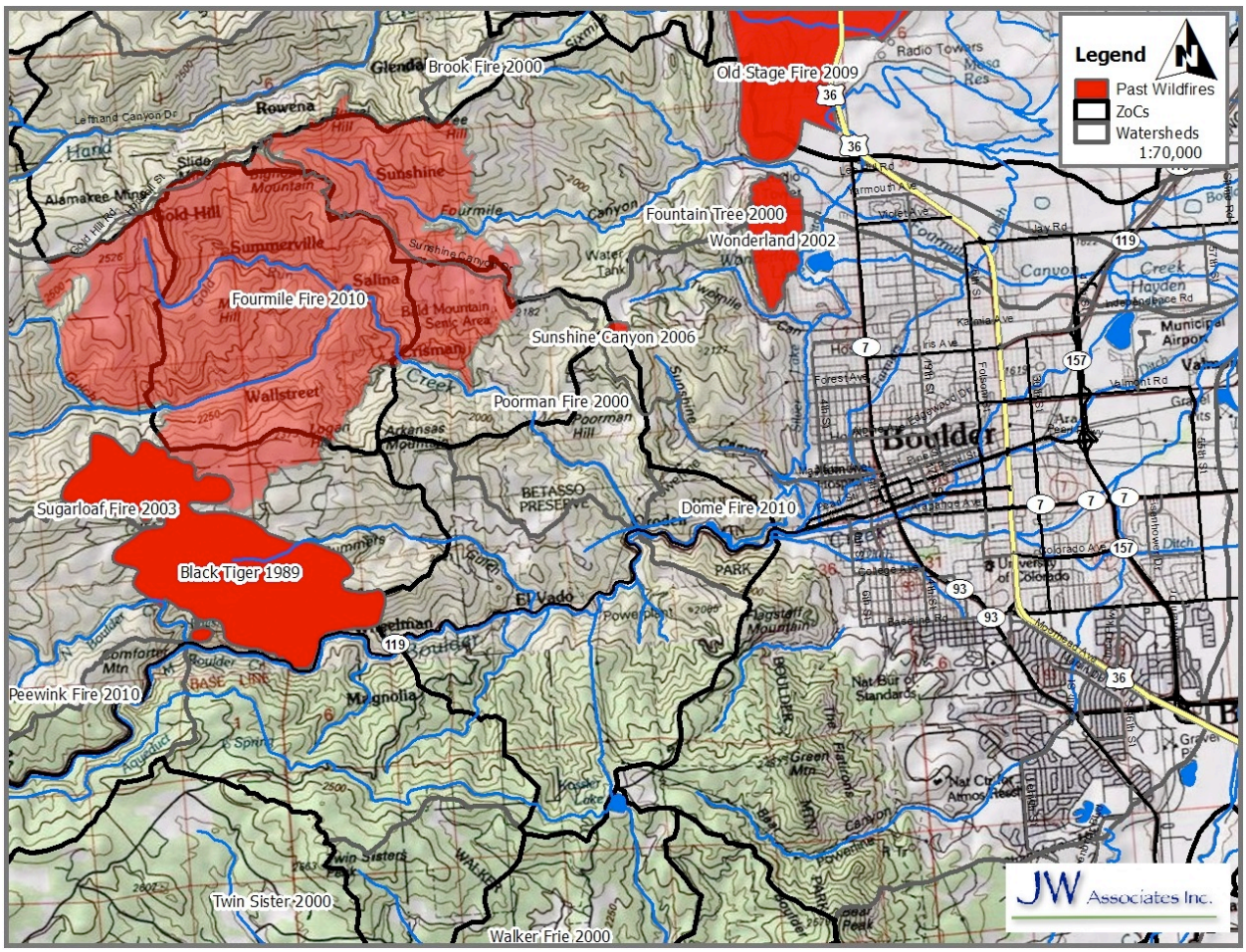


Figure 69. Four Mile Creek ZoC Past Fires

Four Mile Creek Access

The Four Mile Creek and Farmers Ditch ZoC have good access throughout with the exception of the southern portion of the Farmers Ditch ZoC (Figure 70).

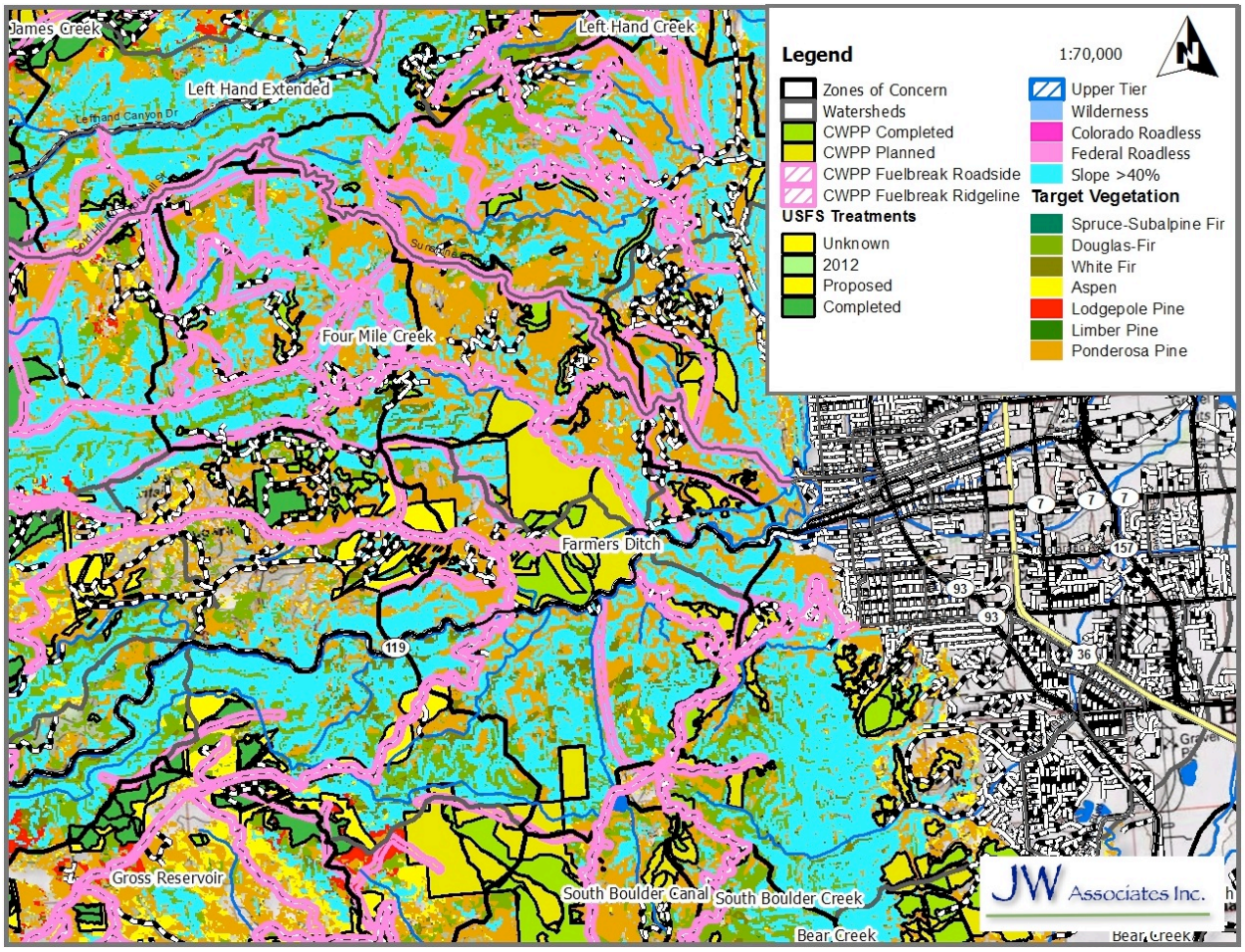
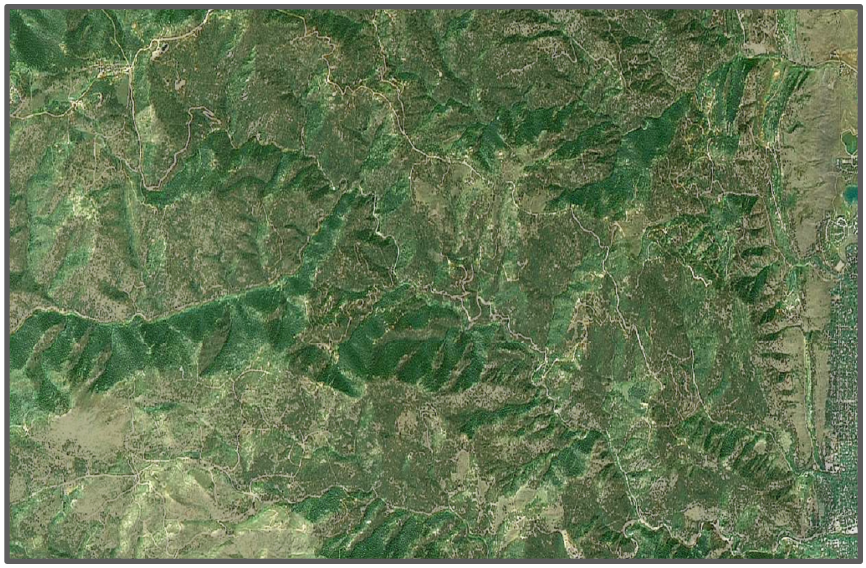


Figure 70. Four Mile Creek ZoC Opportunities

Four Mile Creek Opportunities

Mechanical treatment opportunities are very highly constrained within these ZoC by the extensive steep slopes and the resultant poor access. The ownership pattern of mixed BLM and private lands resulting from old mining activity in the northern portion of the Four Mile ZoC is very problematic when attempting to locate property boundaries and implement management activities. Here, use of Good Neighbor Authorities in conjunction with the BLM may prove a useful tool for conducting necessary work. Because of the difficult terrain in many areas, much of the planned treatments involve strategic roadside and ridgetop fuelbreaks, as shown on Figure 70 and the Boulder County CWPP. These treatments are important to develop and maintain as locations from which defensive fire suppression actions can take place.

The photo reveals large islands with heavy tree cover, but also many areas without trees or with low density forest cover. These latter areas are important to maintain and expand where possible, to allow fires to burn with lower severity and serve as natural locations to attempt to stop fires that could emerge from the heavily forested areas.



At these lower elevations and given the primary vegetation types in these areas, treatments in forested areas should focus on restoration of ponderosa pine and greatly reducing densities of 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. Areas dominated by brush can be periodically mowed or masticated, prescribed burned; or on a limited scale, cut by hand crews. Developing a mosaic of different age classes provides important diversity and keeps a larger percentage of the shrub areas in a younger, more succulent condition.

Boulder Reservoir ZoC

This section discusses the Boulder Reservoir and Boulder Feeder Canal ZoC because they are adjacent (Figure 71). Note that the ZoC is shown here in pink crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

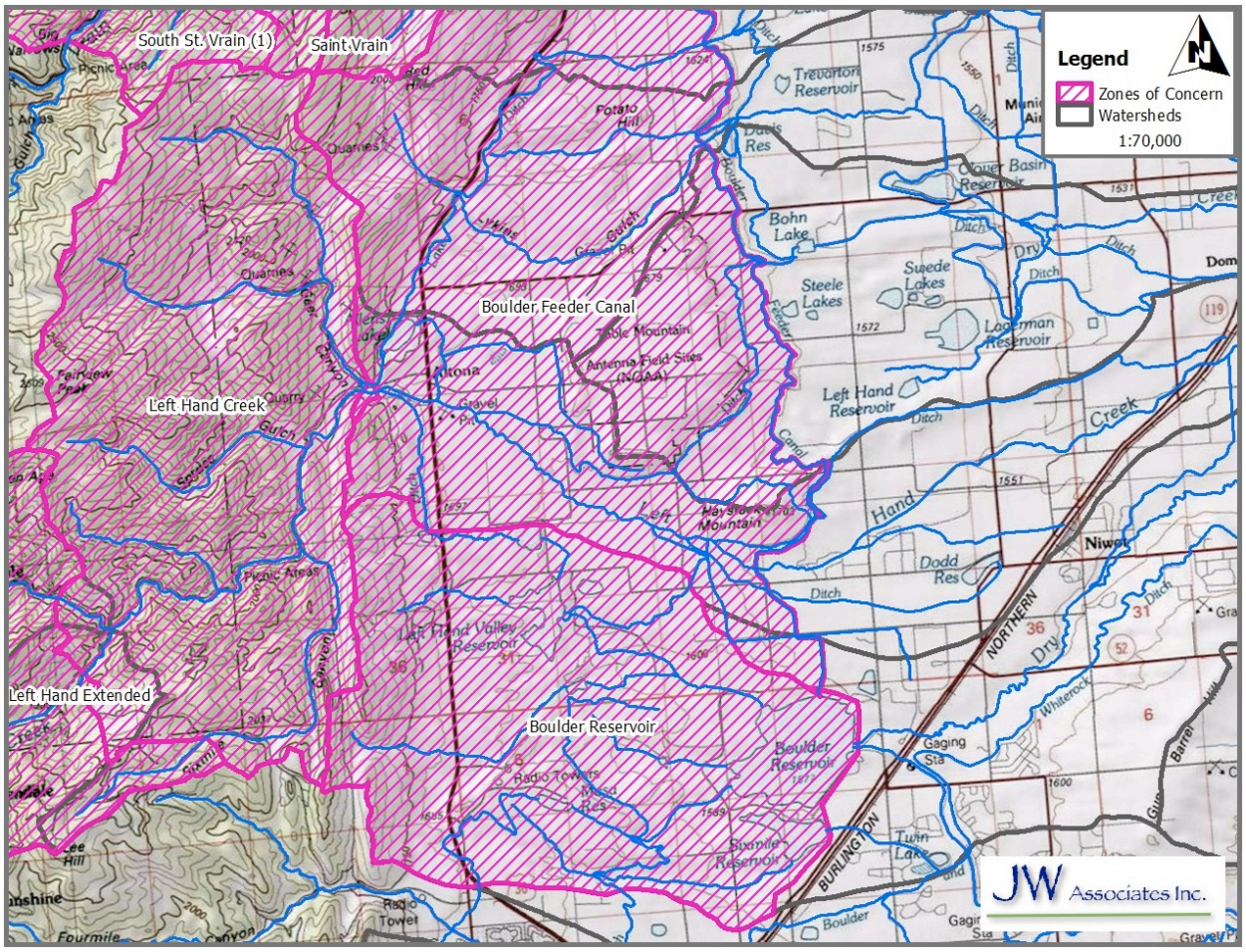


Figure 71. Boulder Reservoir ZoC Location

Boulder Reservoir Ownership

The Boulder Reservoir ZoC is mostly City of Boulder open space lands with some areas of private lands (Figure 72). The Boulder Feeder Canal ZoC is mostly private lands with a large piece of federal land at Table Mountain Antenna Field Site and some areas of Boulder County and City of Boulder open space lands (Figure 72).

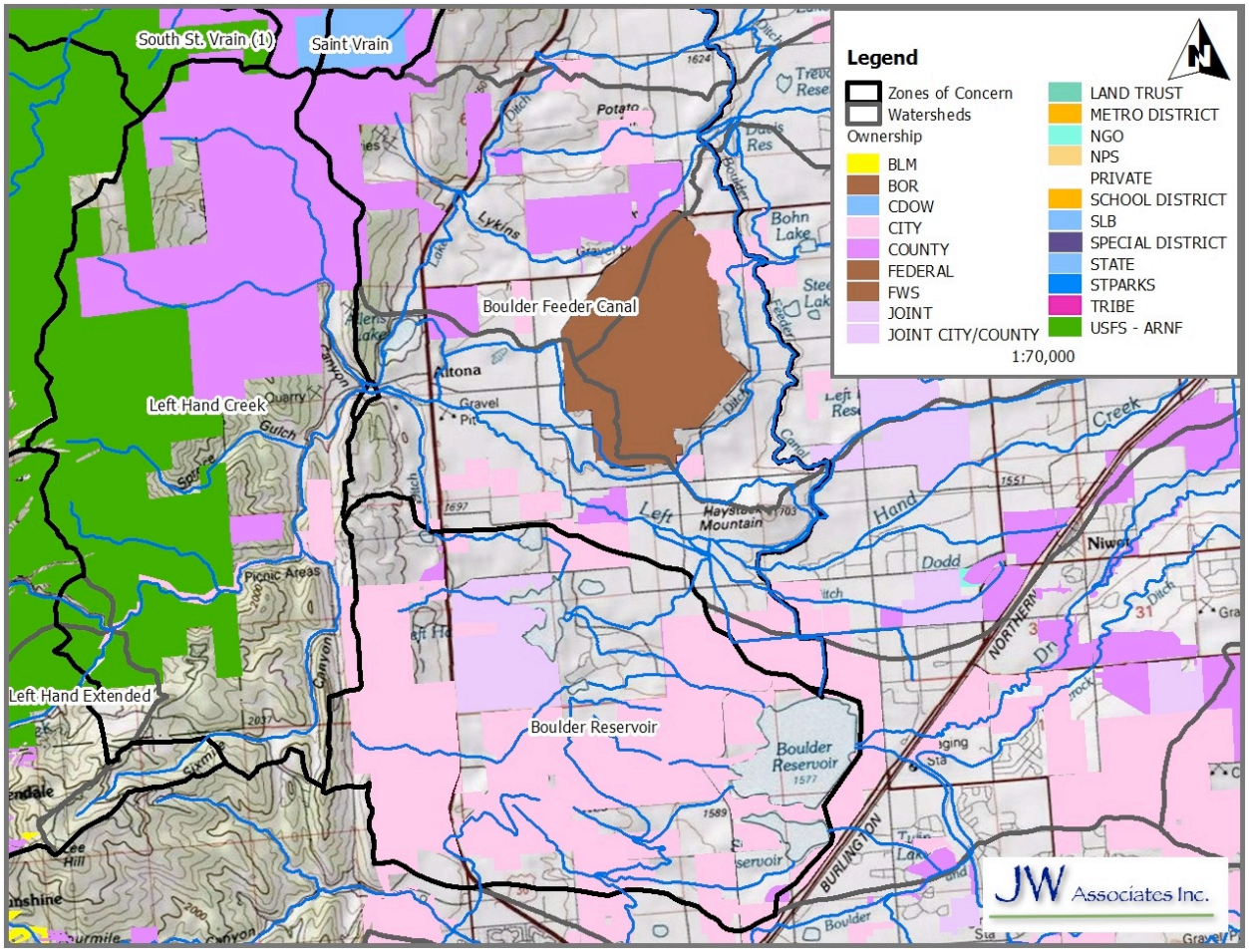


Figure 72. Boulder Reservoir ZoC Ownership

Boulder Reservoir Watershed Priority

The Boulder Reservoir watershed (Figure 73) is ranked Blue overall (Category 2). The Dry Creek watershed that is ranked Green (Category 1 - lowest) overall.

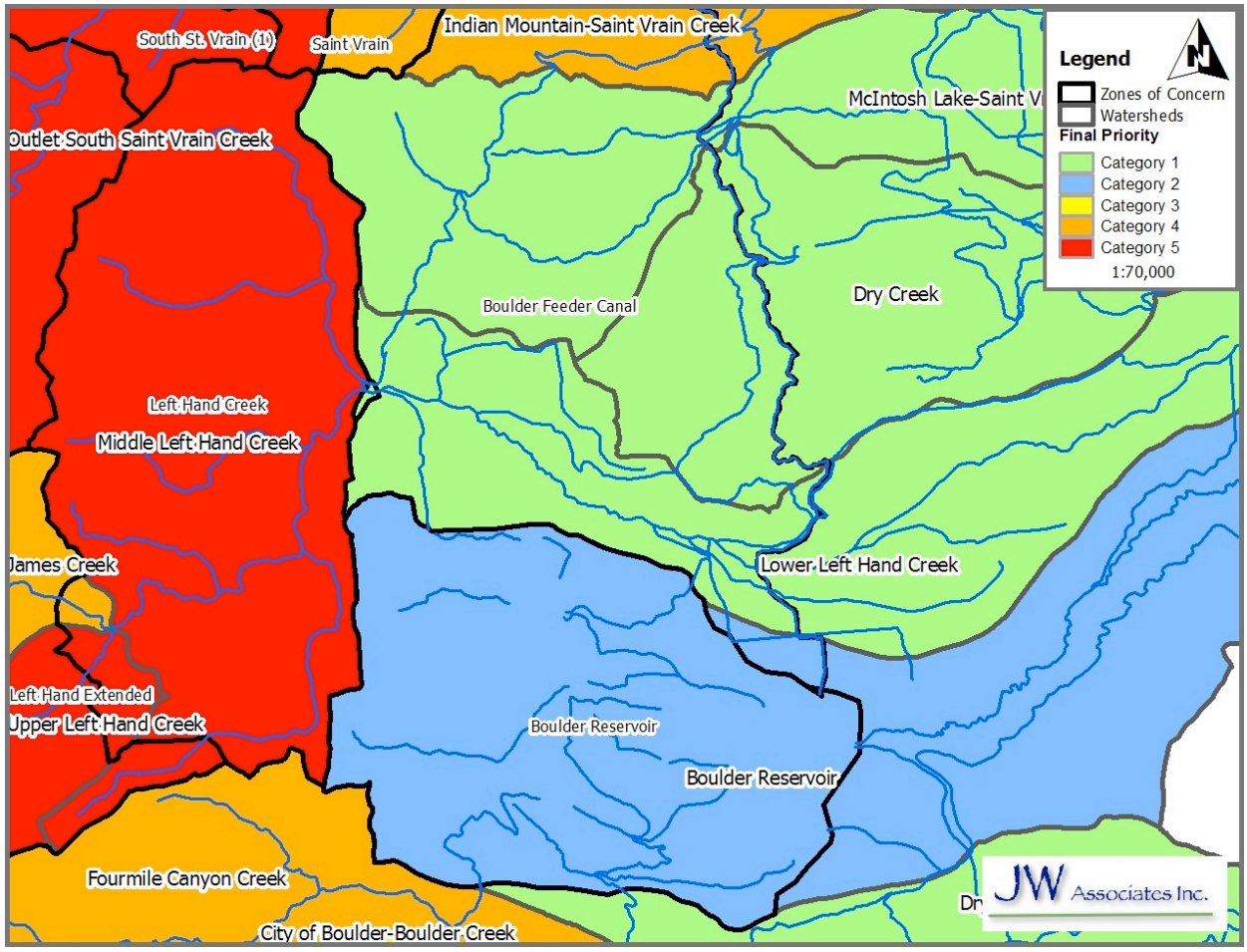


Figure 73. Boulder Reservoir ZoC Watershed Priority

Boulder Reservoir Slopes

These two ZoC are characterized by shallow slopes throughout (Figure 74), except for a small area of steep slopes at the beginning of the foothills in the extreme western portions.

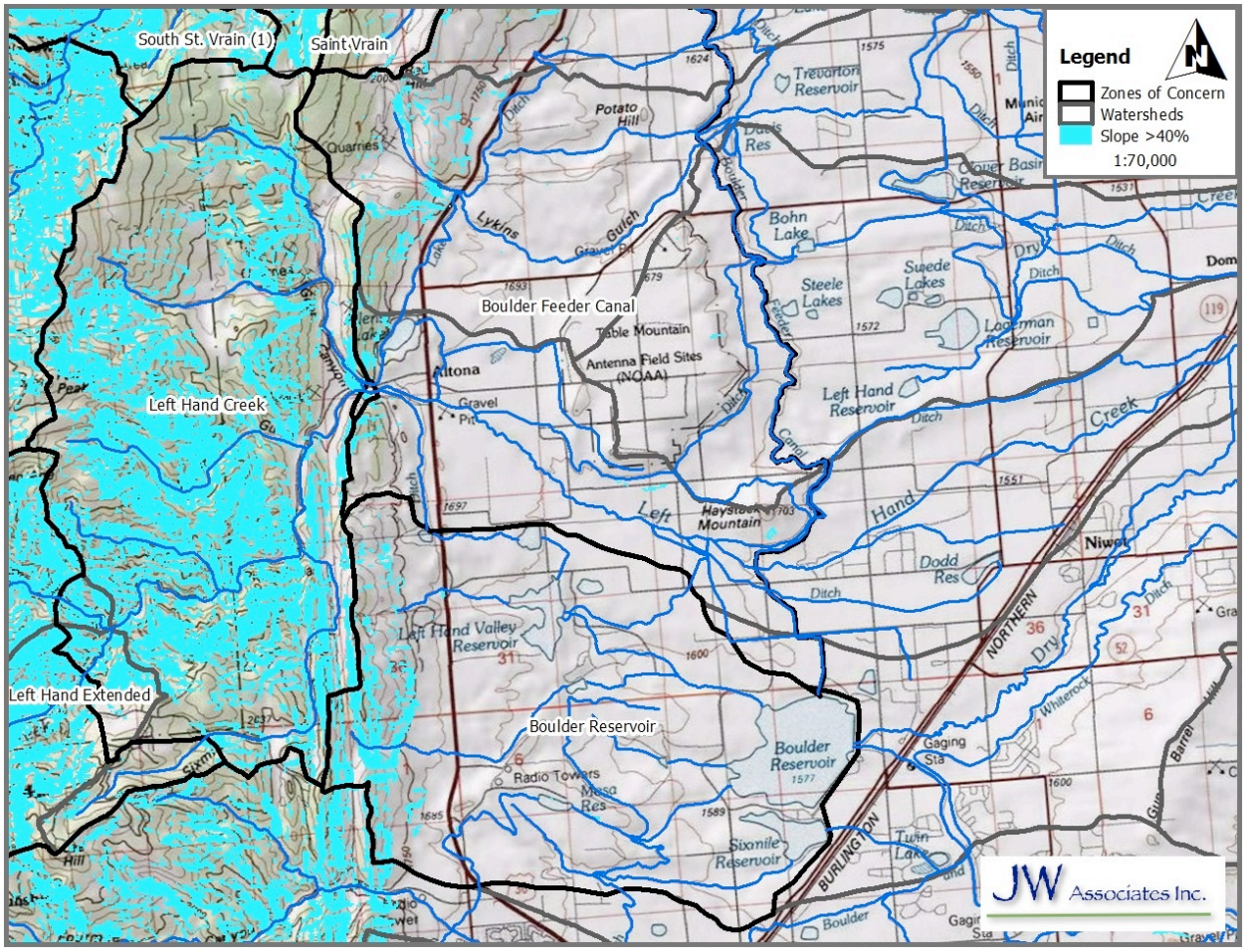


Figure 74. Boulder Reservoir ZoC Slope

Boulder Reservoir Special Management Areas

There are no special management areas in these ZoC (Figure 75).

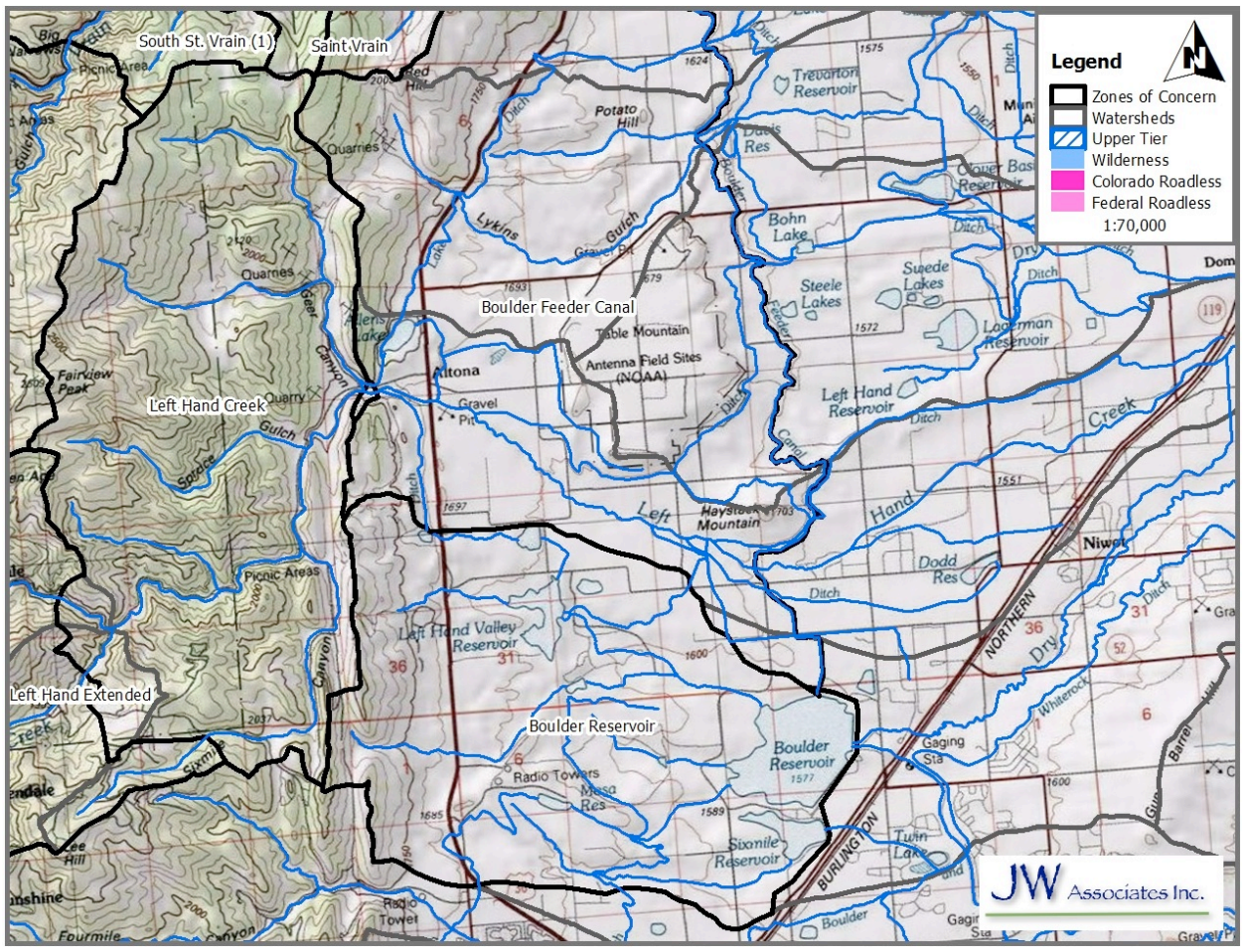


Figure 75. Boulder Reservoir ZoC Special Areas

Boulder Reservoir Vegetation

The Boulder Reservoir ZoC is mostly grassland in the eastern portion (Figure 76). The vegetation then transitions to mixed sagebrush and and ponderosa pine, changing to mostly ponderosa pine of the western extreme of the ZoC. The Boulder Feeder Canal ZoC is mostly grasslands, with some larger areas of sagebrush (Figure 69). Some of the western extent of this ZoC is in ponderosa pine.

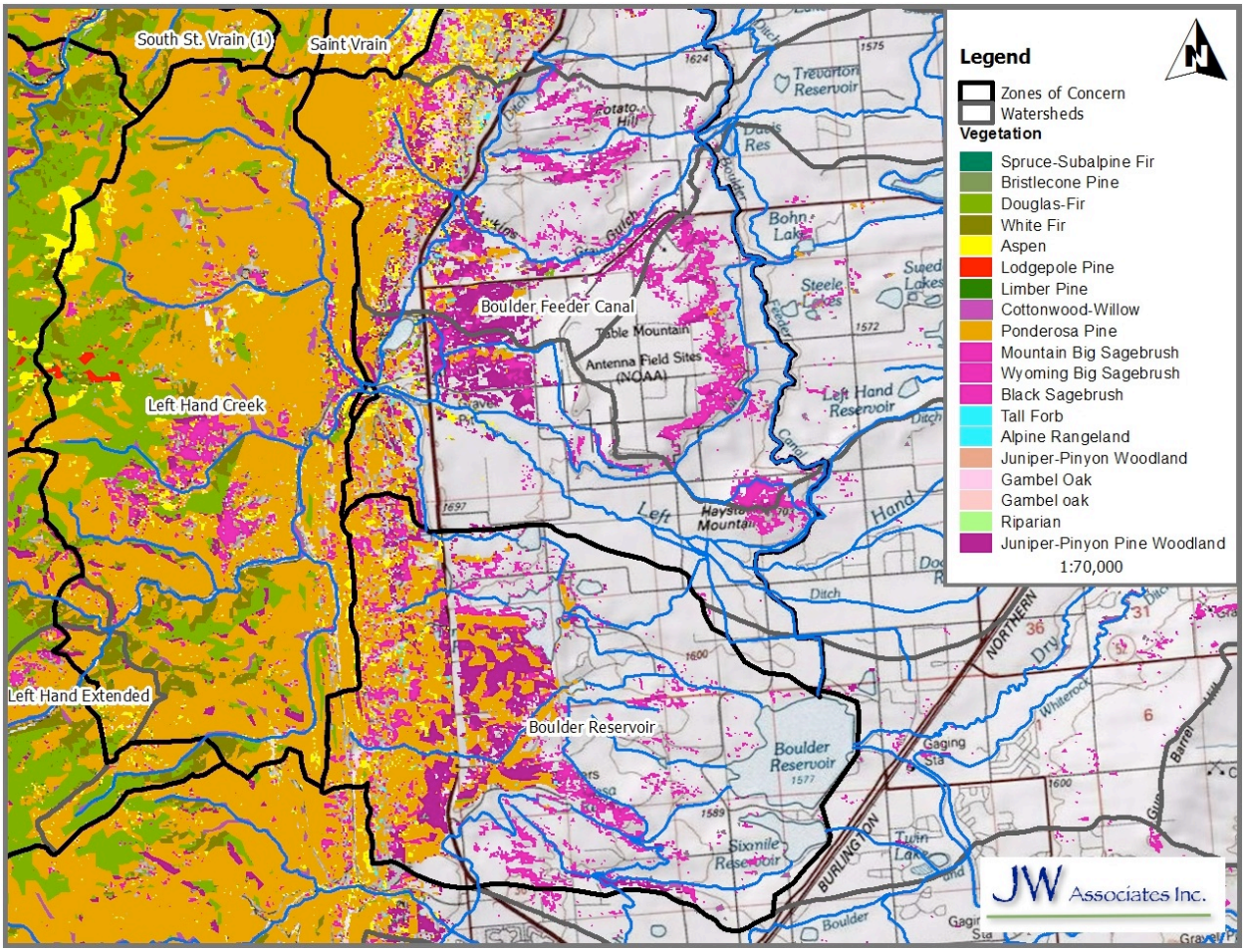


Figure 76. Boulder Reservoir ZoC Vegetation

Boulder Reservoir Past Fires

There have been several fires that have been mapped within these ZoC (Figure 77). The Elk Mountain Fire in 2006 covered nearly 2,500 acres in the Boulder Feeder Canal ZoC mostly in grasslands and sagebrush. The Mountain Ridge Fire in 2000, North Foothills Fire in 2005 and Lykins Fire in 2005 all burned in the Boulder Feeder Canal ZoC covering relatively small areas but burned mostly in ponderosa pine. The Old Stage Fire in 2009 covered nearly 3,200 acres in the Boulder Reservoir ZoC covering nearly all of the ponderosa pine in that ZoC. The Llama Ranch Fire in 2009 burned 35 acres mostly in grasslands in portions of both ZoC.

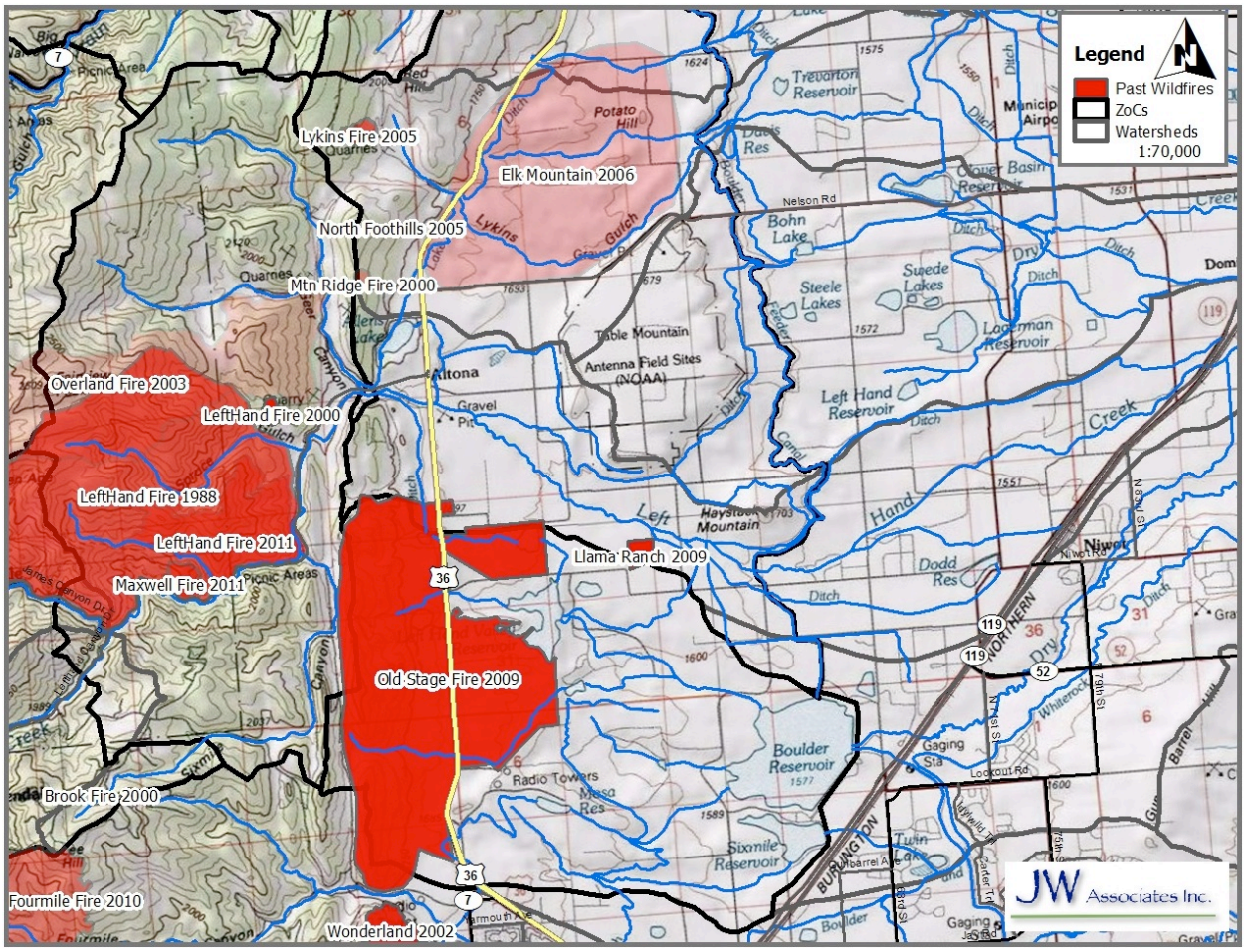


Figure 77. Boulder Reservoir ZoC Past Fires

Boulder Reservoir Access

The Boulder Reservoir ZoC has an extensive existing road network, although few access roads exist in the ponderosa pine areas in the western portion (Figure 78). The Boulder Feeder Canal ZoC also has an extensive road network but few roads in the western portions where the ponderosa pine forests are located.

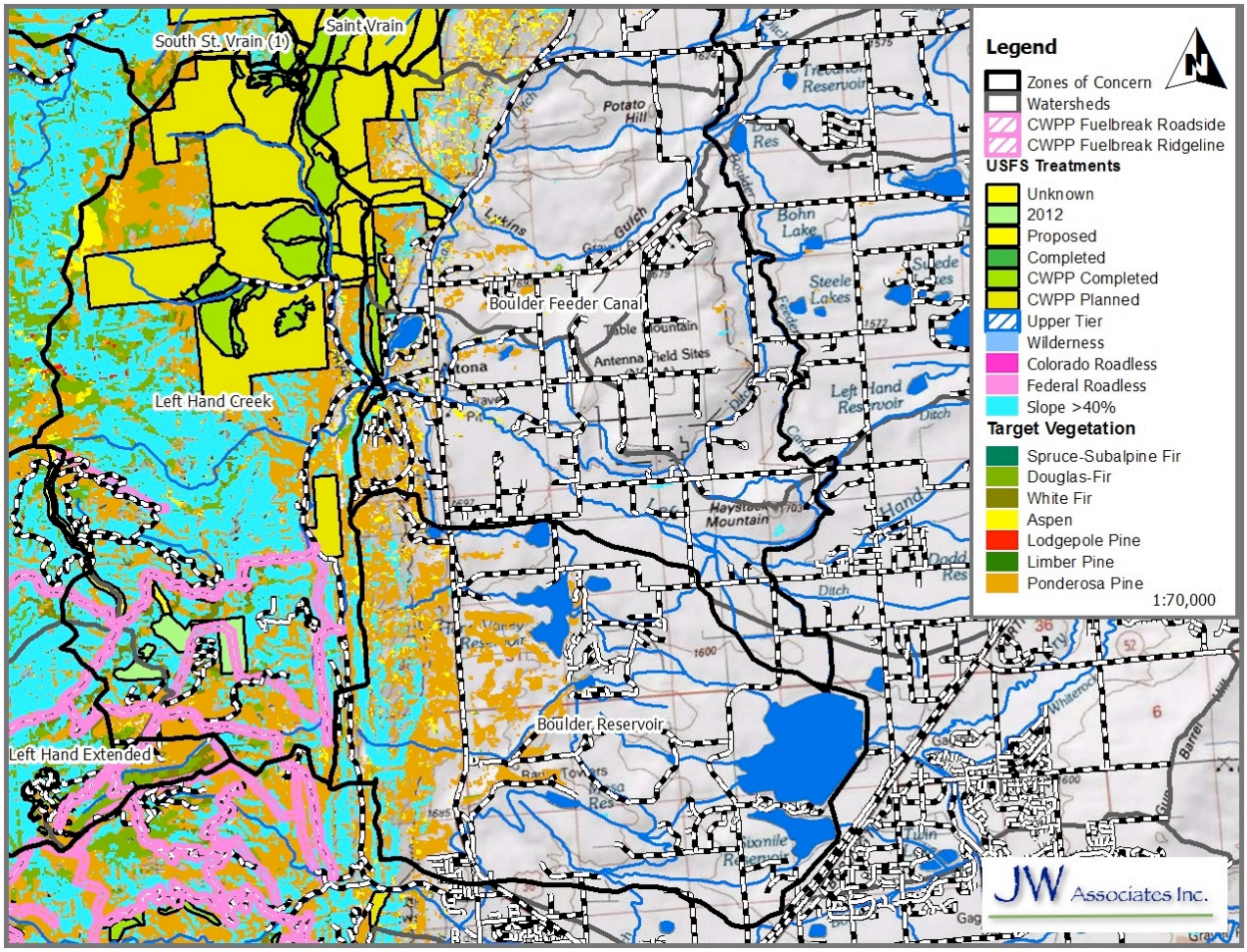


Figure 78. Boulder Reservoir ZoC Opportunities

Boulder Reservoir Opportunities

There are limited treatment opportunities or needs within these ZoC because their location is primarily to the east of the foothills. Typical forest fuels are found along a relatively narrow strip of the western edge of the Boulder Reservoir ZoC and in a wedge-shaped area in the northwest corner of the Boulder Feeder Canal ZoC. In addition, several of Boulder County's large wildfires have burned in these areas, reducing forest densities. The photo to the right shows the openings and more-open forested conditions resulting from these fires in a portion of these ZoC.

Figure 78 along with the Boulder County CWPP shows that many treatments are planned or have been completed in the northwest corner of the Boulder Feeder Canal ZoC. At these lower elevations and given the primary vegetation types in these areas, treatments in forested areas should focus on restoration of ponderosa pine and greatly reducing densities of 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. Areas dominated by brush can be periodically mowed or masticated, prescribed burned; or on a limited scale, cut by hand crews. Developing a mosaic of different age classes provides important diversity and keeps a larger percentage of the shrub areas in a younger, more succulent condition.

East of the foothills, grass and brush lands would also benefit ecologically from periodic mowing or mastication, or prescribed burning. Understand, however, that such treatments will provide only minor benefit from a hazardous fuels reduction and watershed protection standpoint.

South Boulder Creek ZoC

This section discusses the Marshall Lake, South Boulder Ditch, Bear Creek, South Boulder Creek and South Boulder Canal ZoC because they are adjacent or overlapping (Figure 79). Note that the ZoC is shown here in pink crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

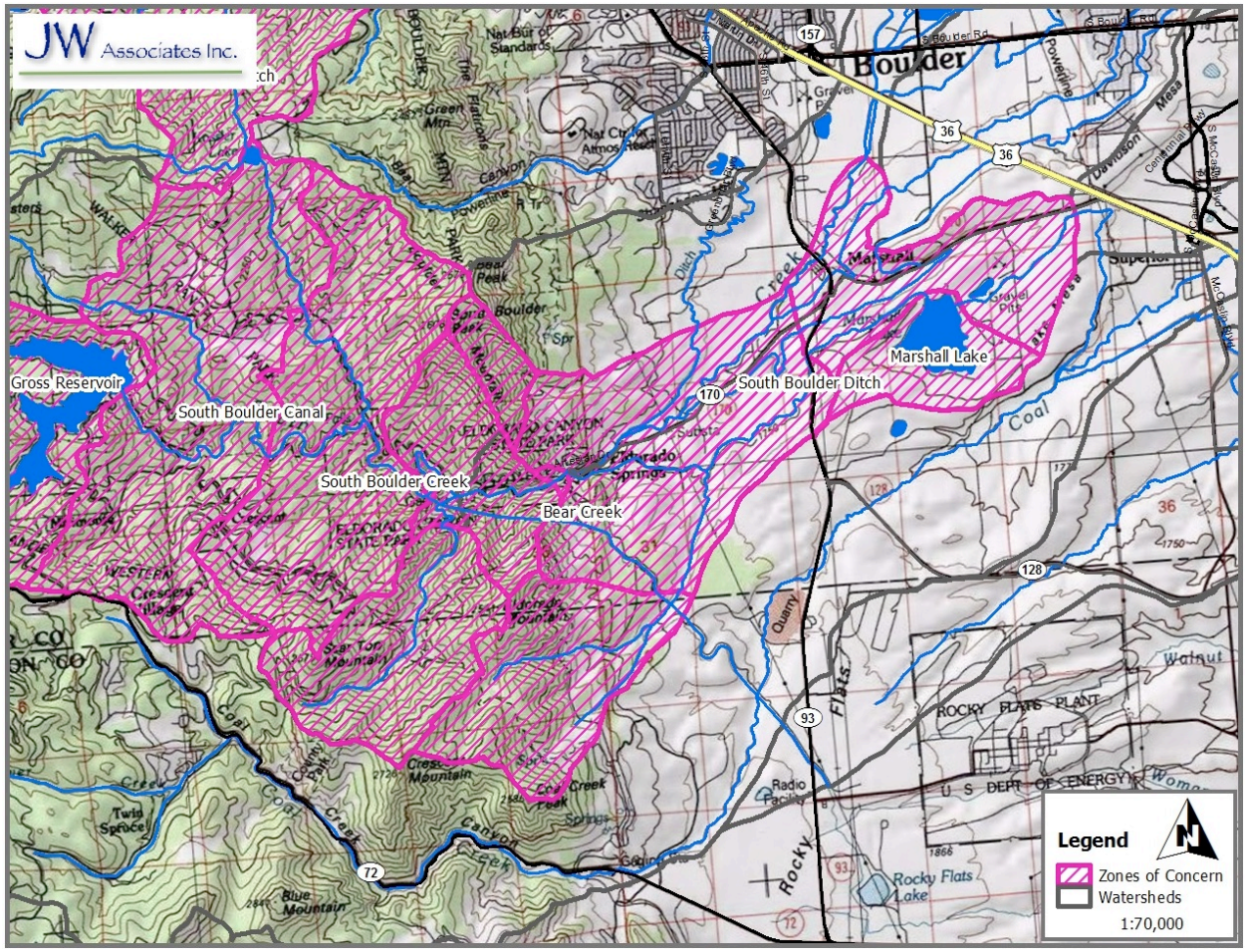


Figure 79. South Boulder Creek ZoC Location

South Boulder Creek Ownership

The Marshall Lake and South Boulder Creek ZoC are mostly City of Boulder open space lands, with some private ownership (Figure 80). The Bear Creek ZoC is mostly City of Boulder open space lands but also includes Eldorado Canyon State Park in the ZoC. The South Boulder Creek ZoC is a mixture of private, BLM, Boulder County open space, City of Boulder open space, Walker Ranch and Eldorado Canyon State Park. The South Boulder Canal ZoC has a similar ownership pattern to the South Boulder Creek ZoC with a larger portion of Boulder County open space lands (Figure 80).

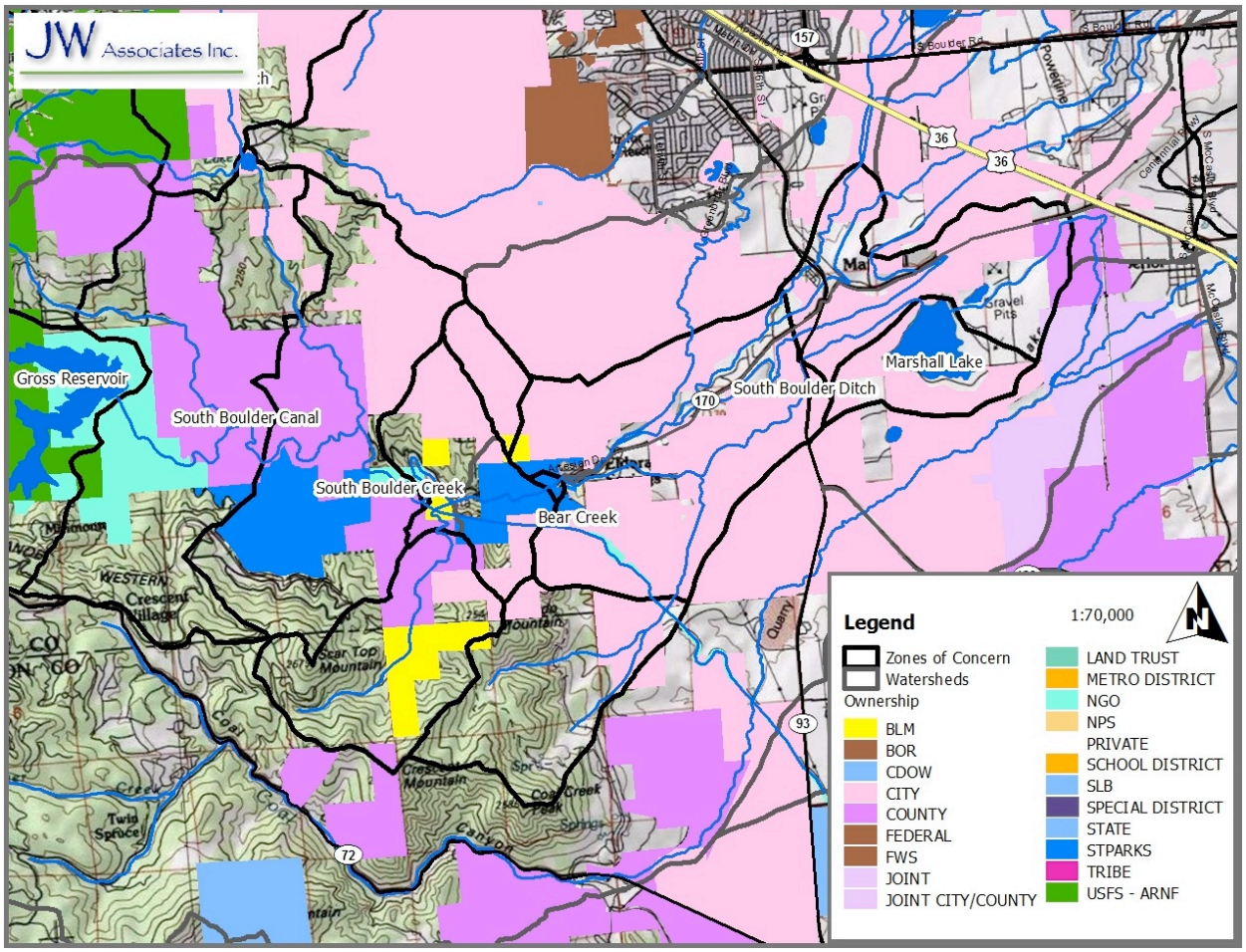


Figure 80. South Boulder Creek ZoC Ownership

South Boulder Creek Watershed Priority

The Lower South Boulder Creek watershed (Figure 81) is ranked Red (Category 5 - highest) overall and for Soil Erodibility and Composite Hazard. It is also ranked Orange (Category 4) for Wildfire Hazard. The Middle South Boulder Creek watershed is ranked Red (Category 5 - highest) overall, and for Soil Erodibility and Composite Hazard. It is also ranked Orange (Category 4) for Wildfire Hazard.

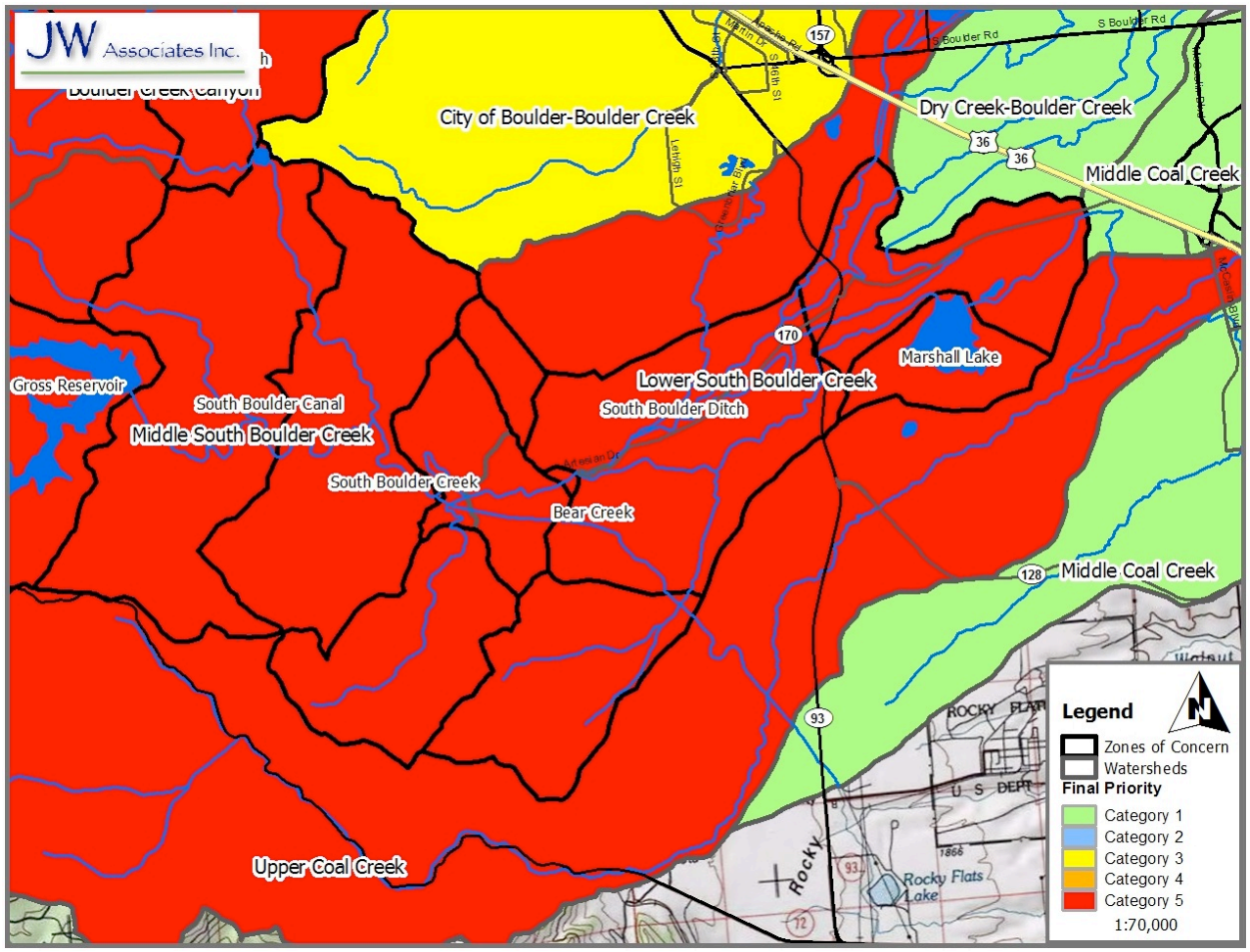


Figure 81. South Boulder Creek ZoC Watershed Priority

South Boulder Creek Slopes

The beginning of the foothills creates a well defined break within these ZoC that defines the relatively flat ground east of the foothills and the steep ground at the beginning of the foothills (Figure 82).

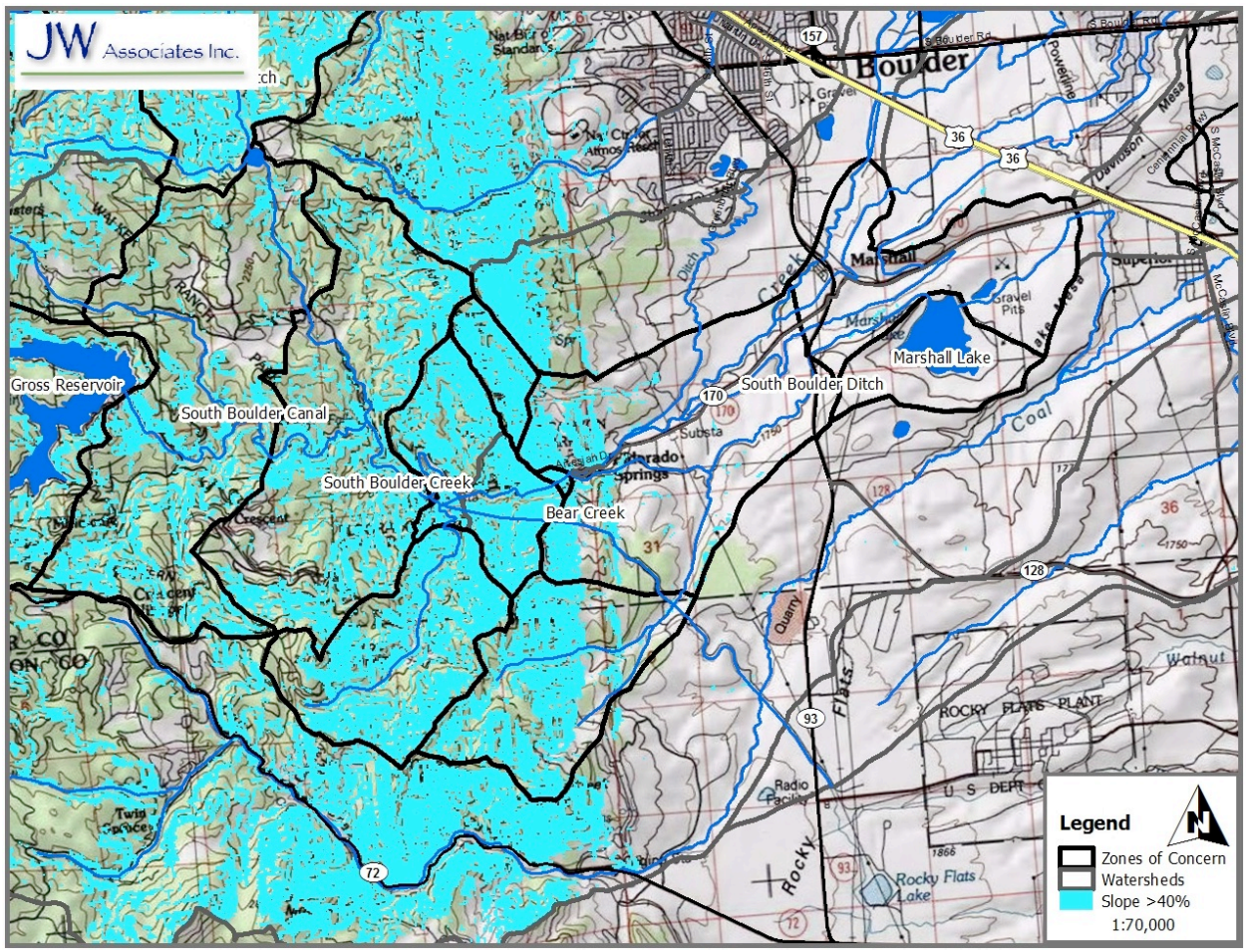


Figure 82. South Boulder Creek ZoC Slope

South Boulder Creek Special Management Areas

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

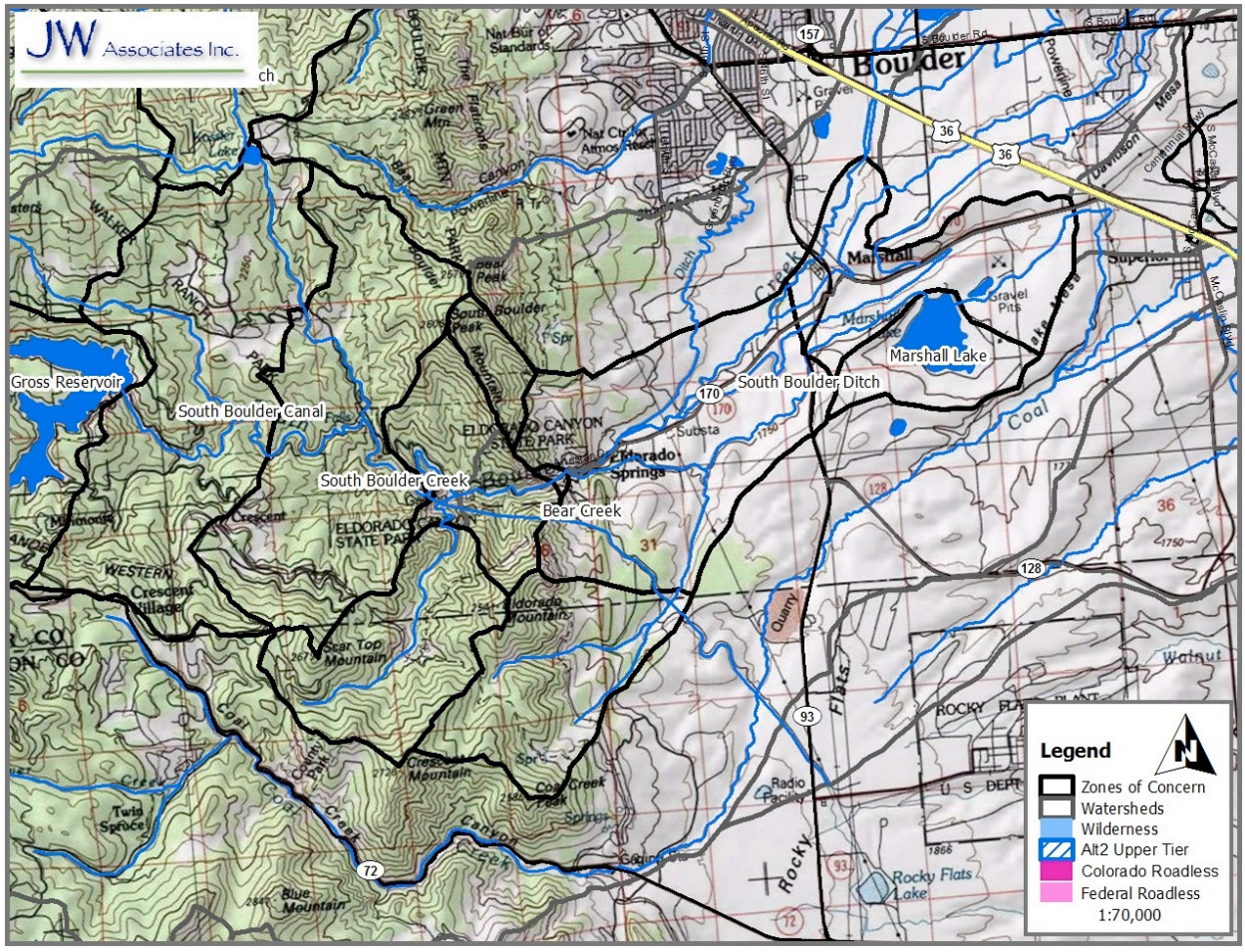


Figure 83. South Boulder Creek ZoC Special Areas

South Boulder Creek Vegetation

The Marshall Lake ZoC is on the plains and is mostly grasslands (Figure 84). The South Boulder Ditch ZoC is mostly on the plains and therefore mostly grasslands with some areas of sagebrush, which then transitions to the foothills and some areas of ponderosa pine on the western edge of the ZoC. The Bear Creek ZoC begins on the plains in grasslands and sagebrush then transitions to ponderosa pine and some Douglas-fir. The South Boulder Creek and South Boulder Canal ZoC are mostly ponderosa pine and Douglas-fir.

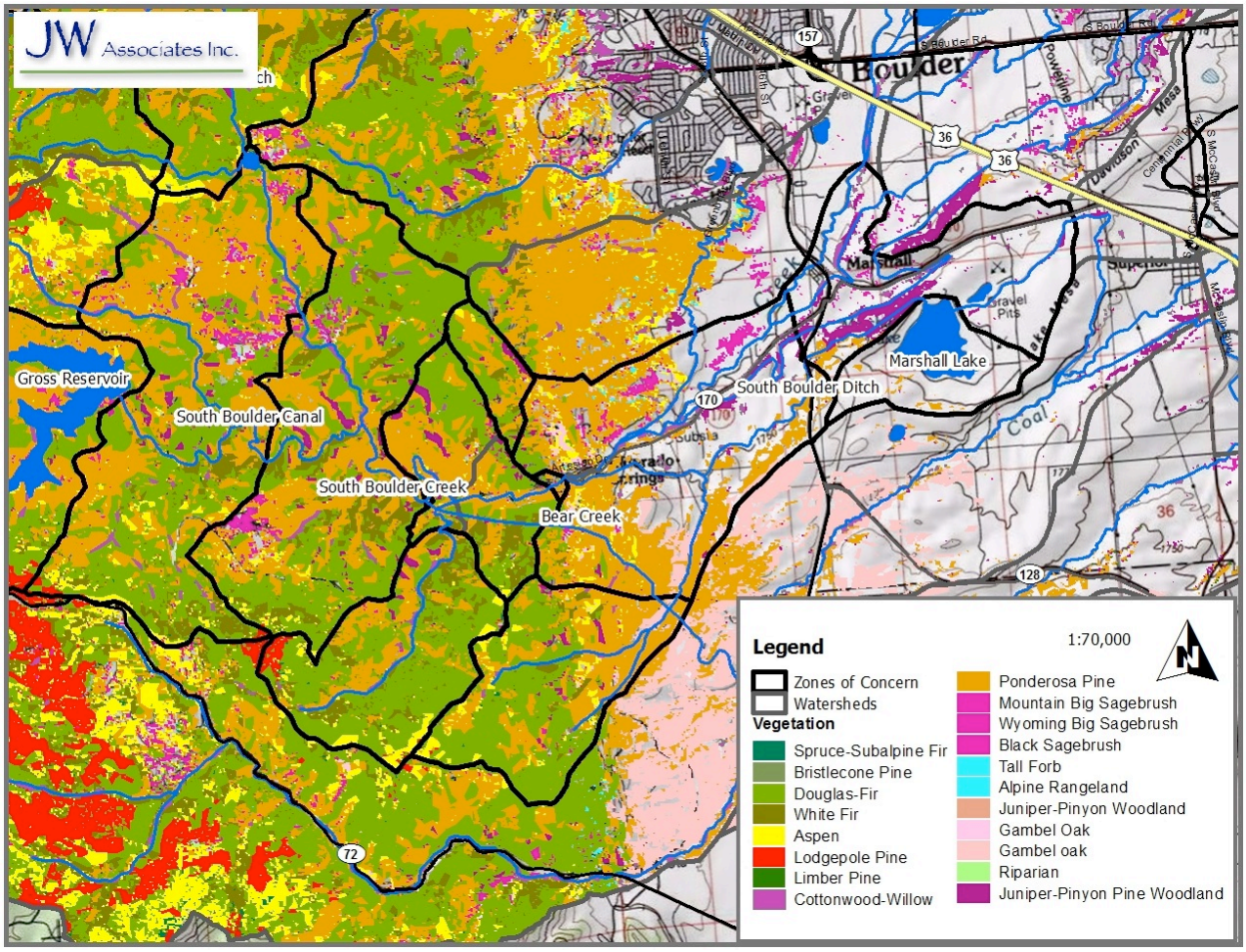


Figure 84. South Boulder Creek ZoC Vegetation

South Boulder Creek Past Fires

There are few recent past fires that have been mapped within these ZoC (Figure 85). The Walker Fire burned less than 1,100 acres in 2000 in the upper portions of the South Boulder Canal and South Boulder Creek ZoC. That fire burned mostly ponderosa pine and Douglas-fir. The Eldorado Springs Fire burned less than 10 acres in 2000 in the South Boulder Creek ZoC. The Lindsay Fire burned less than 20 acres in the South Boulder Ditch ZoC in 2003.

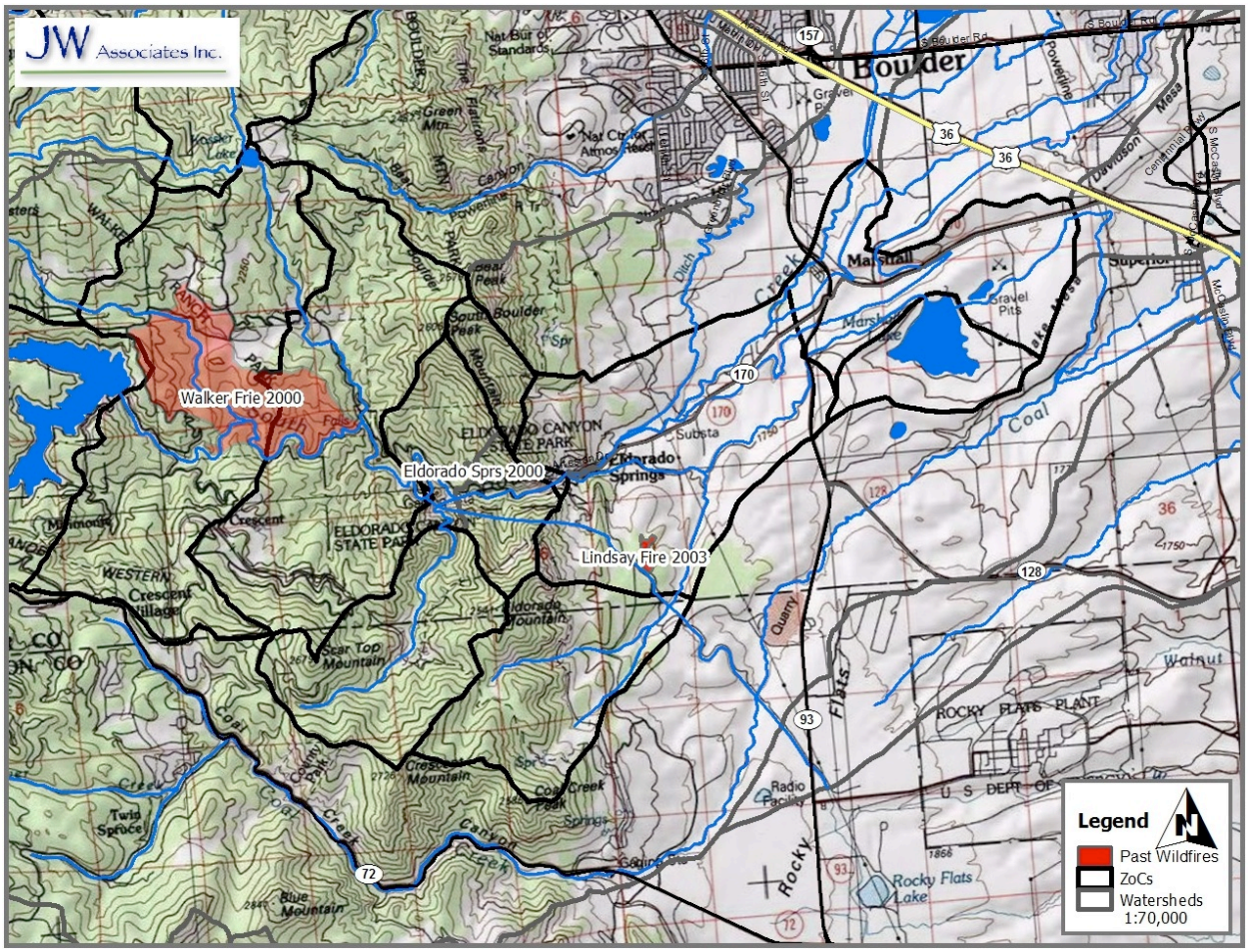


Figure 85. South Boulder Creek ZoC Past Fires

South Boulder Creek Access

The forested areas within these ZoC have limited access from existing roads. Much of this area is open space where development is limited (Figure 86).

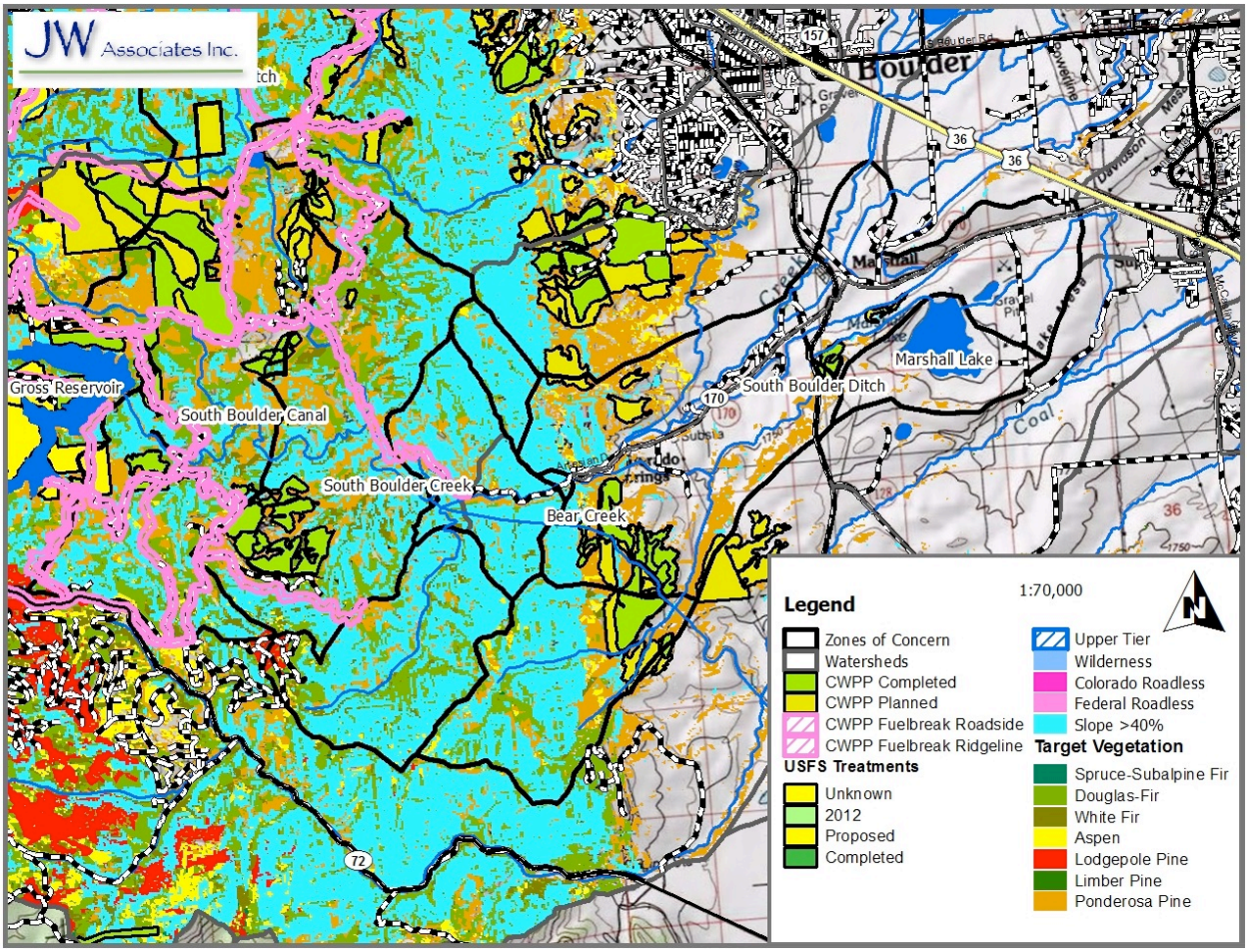


Figure 86. South Boulder Creek ZoC Opportunities

South Boulder Creek Opportunities

East of the foothills and those areas of ponderosa pine found on the flats just east of the foothills have limited treatment opportunities or needs within these ZoC. East of the foothills and ponderosa flats, grass and brush lands would also benefit ecologically from periodic mowing or mastication, or prescribed burning. Understand, however, that such treatments will provide only minor benefit from a hazardous fuels reduction and watershed protection standpoint.

Figure 86 and the Boulder County CWPP shows that many treatments are planned or have been completed on the flats east of the foothills. These treatments are important to help limit fire's ability to move upslope into the steeper portions of the ZoC. At these lower elevations and given the primary vegetation types in these areas, treatments in forested areas should focus on restoration of ponderosa pine and greatly reducing densities of any invading Douglas-fir. Areas dominated by brush can be periodically mowed or masticated, prescribed burned; or on a limited scale, cut by hand crews. Developing a mosaic of different age classes provides important diversity will keep a larger percentage of these shrub areas in a younger, more succulent condition.

West of the foothills, management opportunities are highly restricted by the extensive areas with slopes greater than 40%. Some treatments have been completed and are planned. The majority of the proposed treatments are strategic roadside and ridgetop fuelbreaks. Elsewhere, treatments in forested areas 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.

Gross Reservoir ZoC

This section discusses the Gross Reservoir ZoC (Figure 87). Note that the ZoC is shown here in pink or yellow crosshatching, but in the remaining figures the outlines appear as bold black lines with no crosshatching.

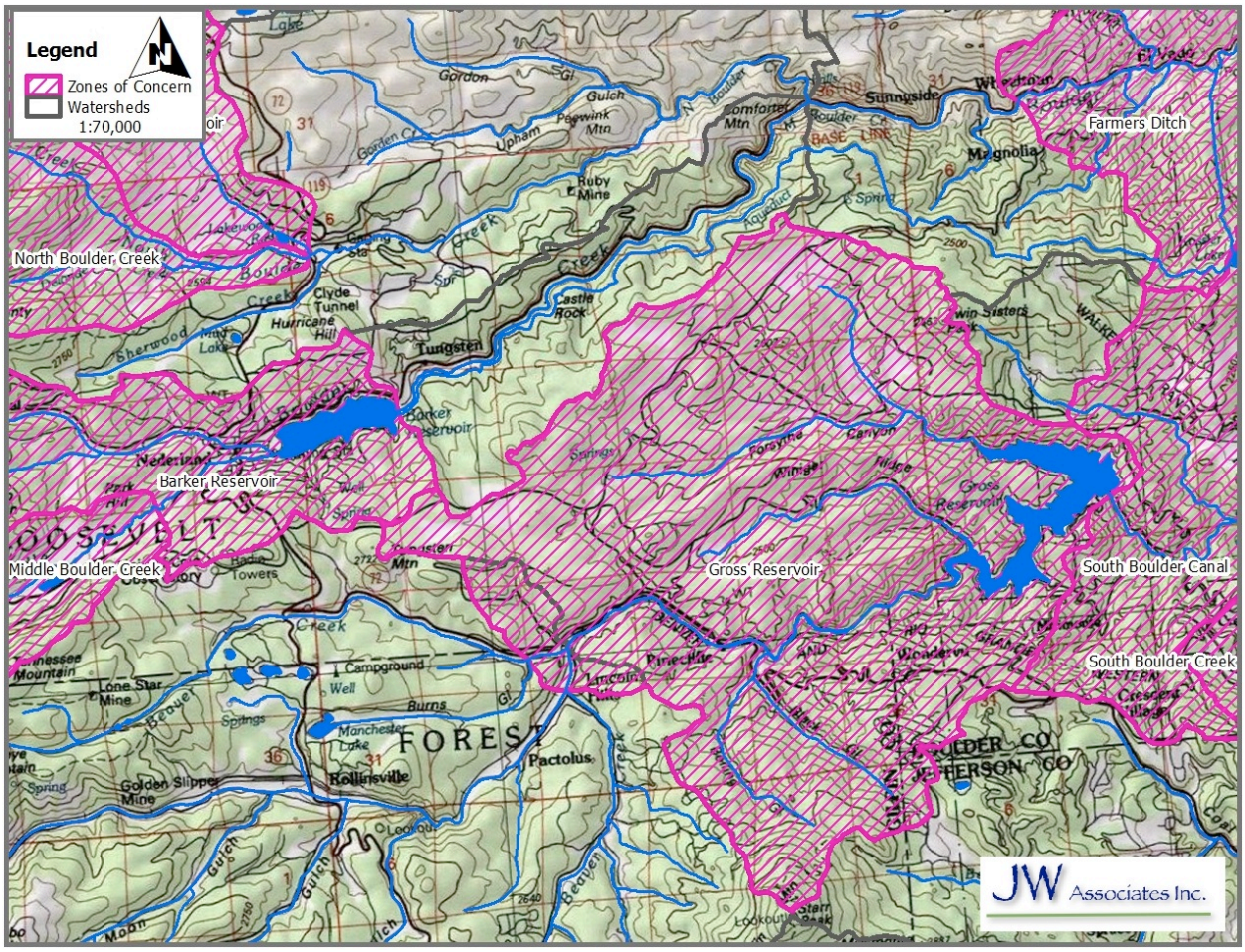


Figure 87. Gross Reservoir ZoC Location

Gross Reservoir Ownership

The Gross Reservoir ZoC is mostly NFS lands with a large portion of private lands and some smaller areas of Boulder County lands (Figure 88). Some of the lands around Gross Reservoir are owned by Denver Water.

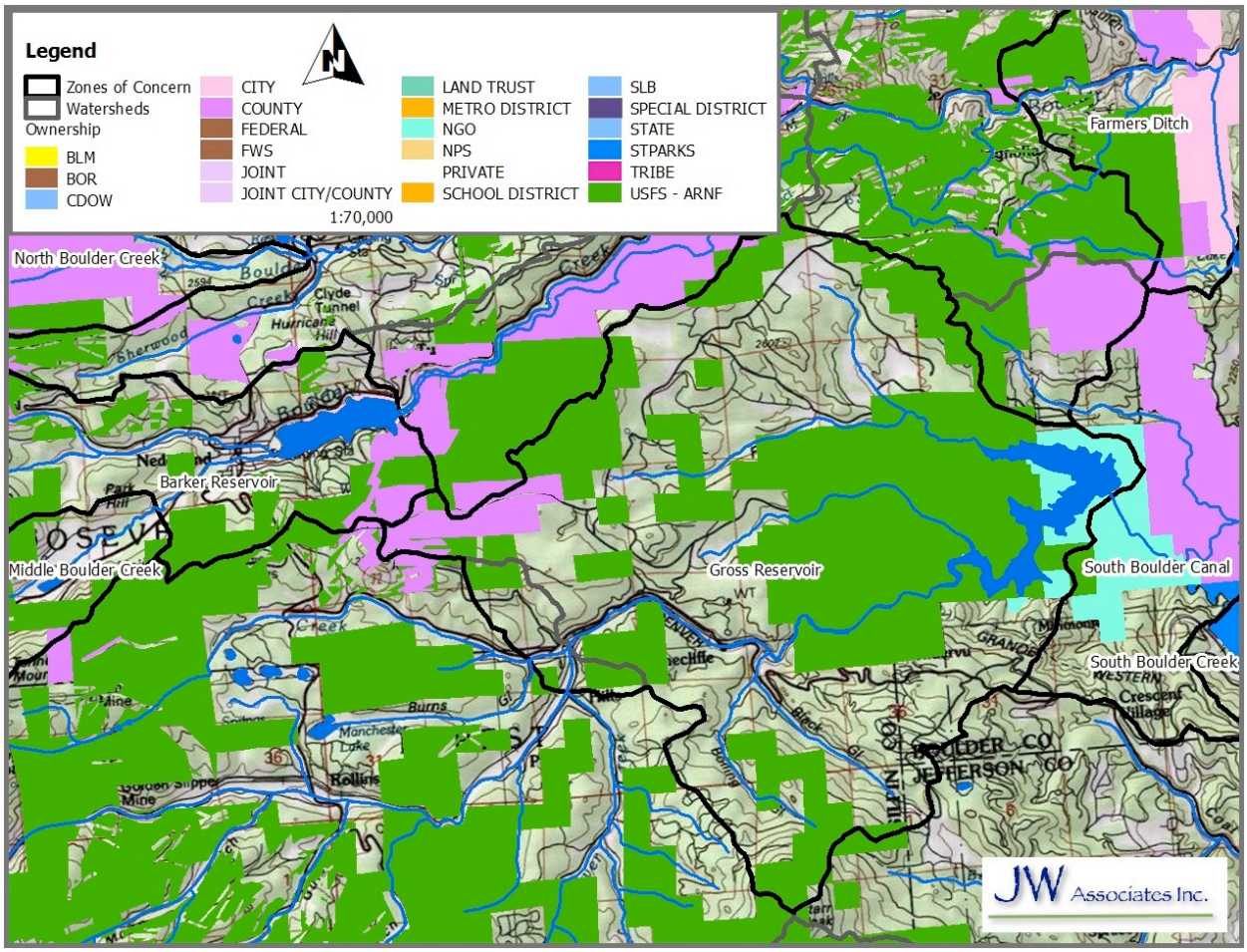


Figure 88. Gross Reservoir ZoC Ownership

Gross Reservoir Watershed Priority

The Middle South Boulder Creek watershed (Figure 89) is ranked Red (Category 5 - highest) overall, and for Soil Erodibility and Composite Hazard. It is also ranked Orange (Category 4) for Wildfire Hazard.

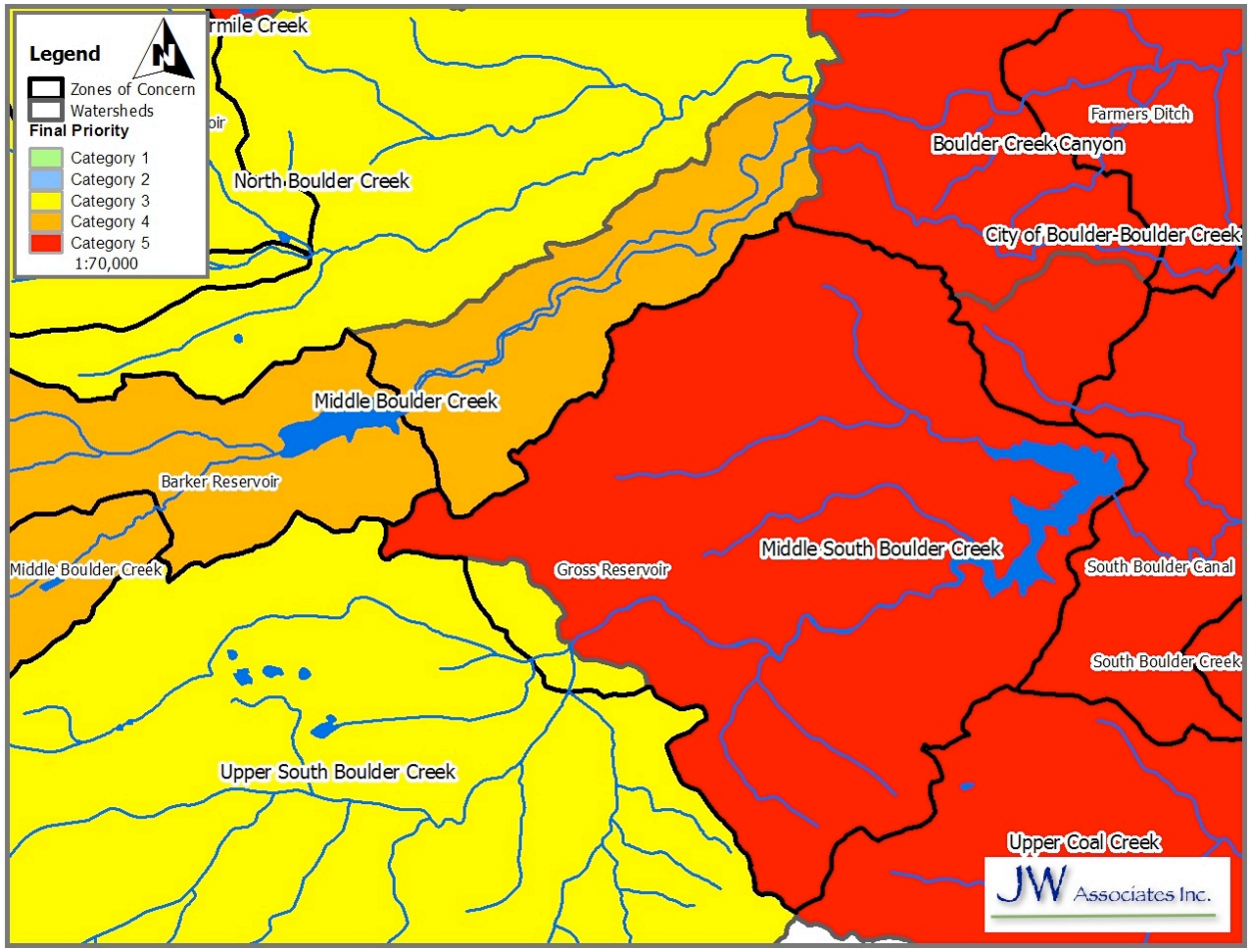


Figure 89. Gross Reservoir ZoC Watershed Priority

Gross Reservoir Slopes

The Gross Reservoir ZoC is characterized by mostly shallow slopes throughout (Figure 90) except for the around South Boulder Creek and the two other main streams flowing into Gross Reservoir.

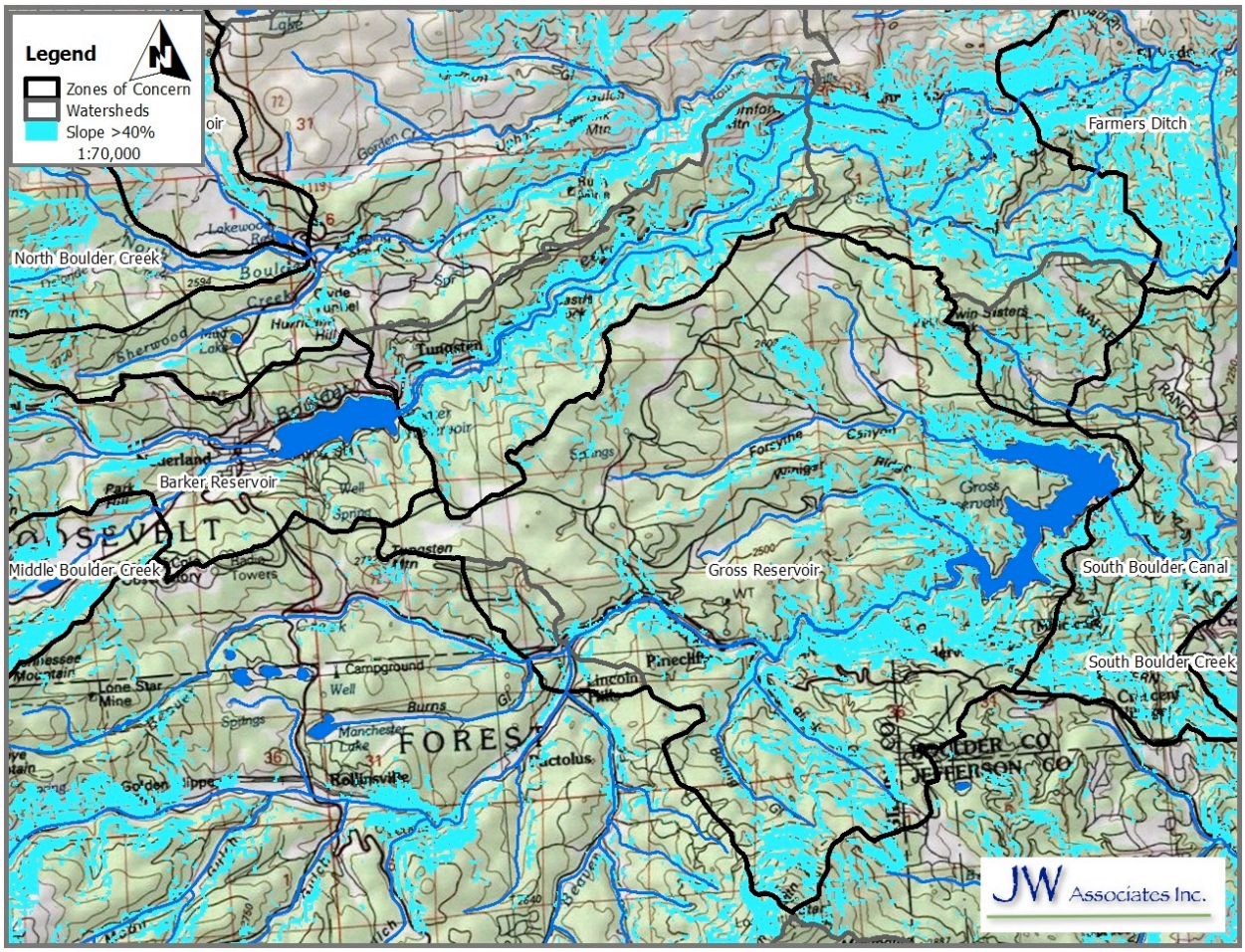


Figure 90. Gross Reservoir ZoC Slope

Gross Reservoir Special Management Areas

There are no special management areas in this ZoC (Figure 91).

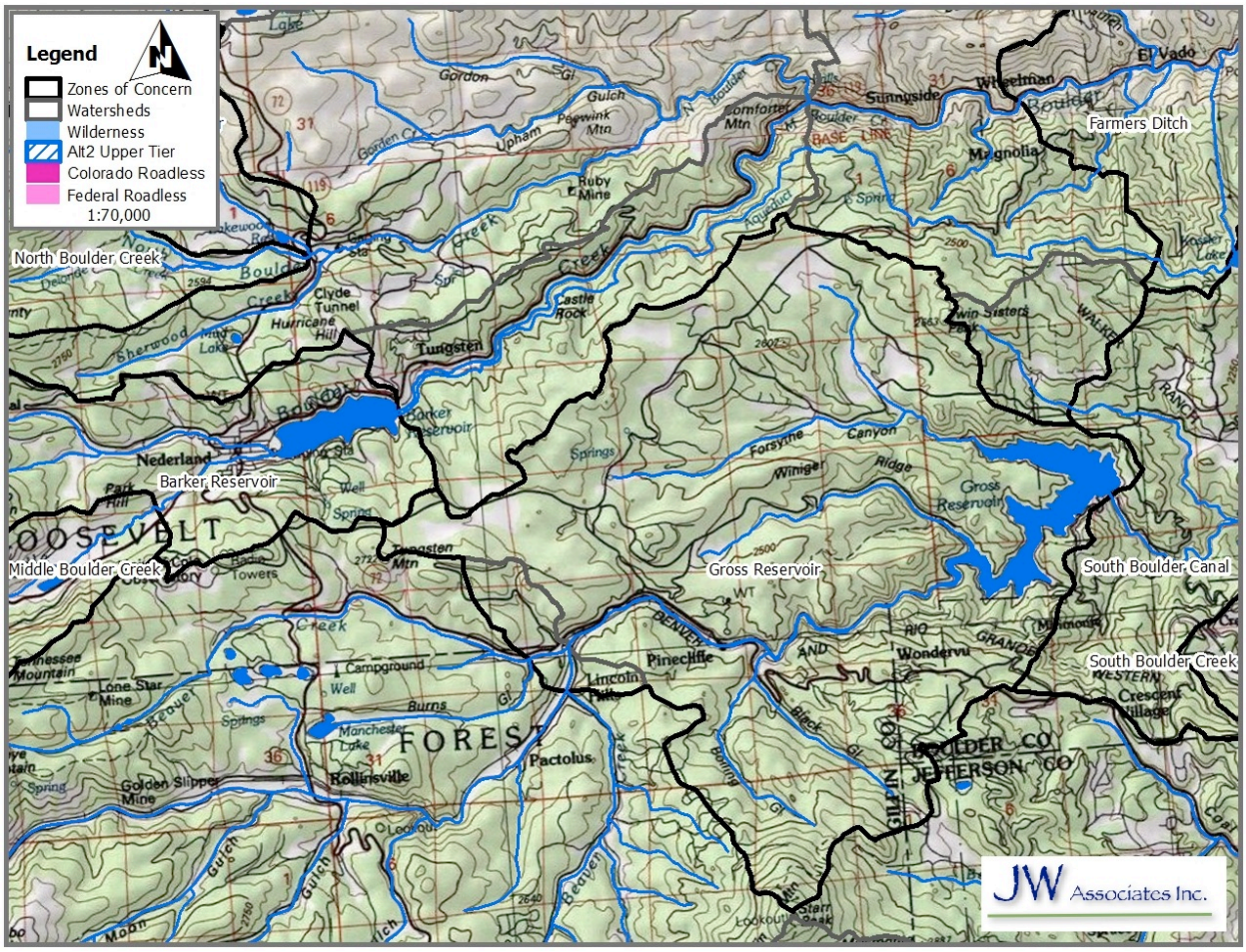


Figure 91. Gross Reservoir ZoC Special Areas

Gross Reservoir Vegetation

The Gross Reservoir ZoC is mostly forested. Ponderosa pine and Douglas-fir occupy most of the area surrounding the reservoir (Figure 92). The northern portion of the ZoC is covered by aspen with ponderosa pine and Douglas-fir scattered throughout. The western portion is covered by ponderosa pine and lodgepole pine. The southern portion is covered mostly in lodgepole pine with some Douglas-fir and aspen.

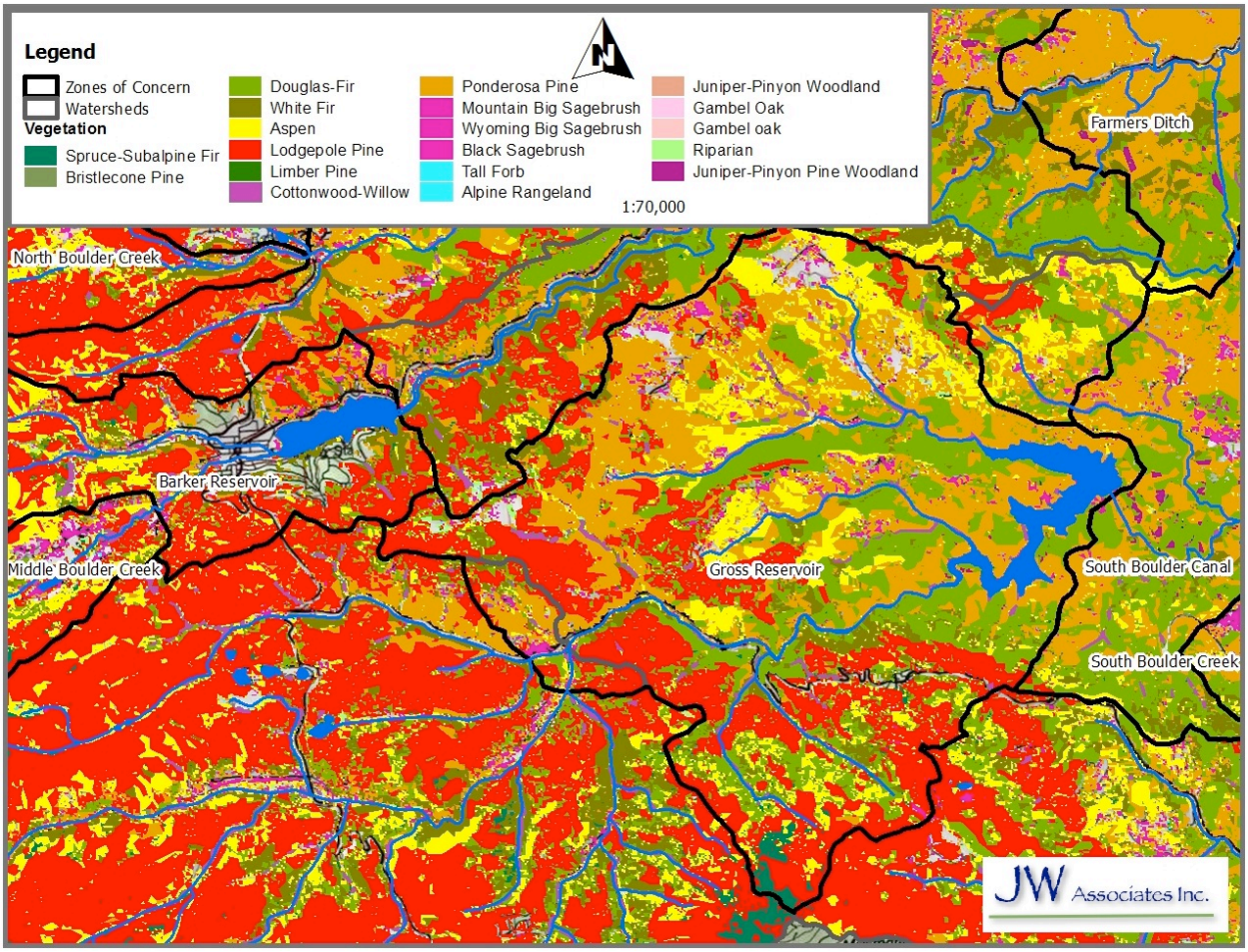


Figure 92. Gross Reservoir ZoC Vegetation

Gross Reservoir Past Fires

There are no recent past fires that have been mapped within the Gross Reservoir ZoC (Figure 93). The Walker Fire burned less than 1,100 acres in 2000 just below of this ZoC.

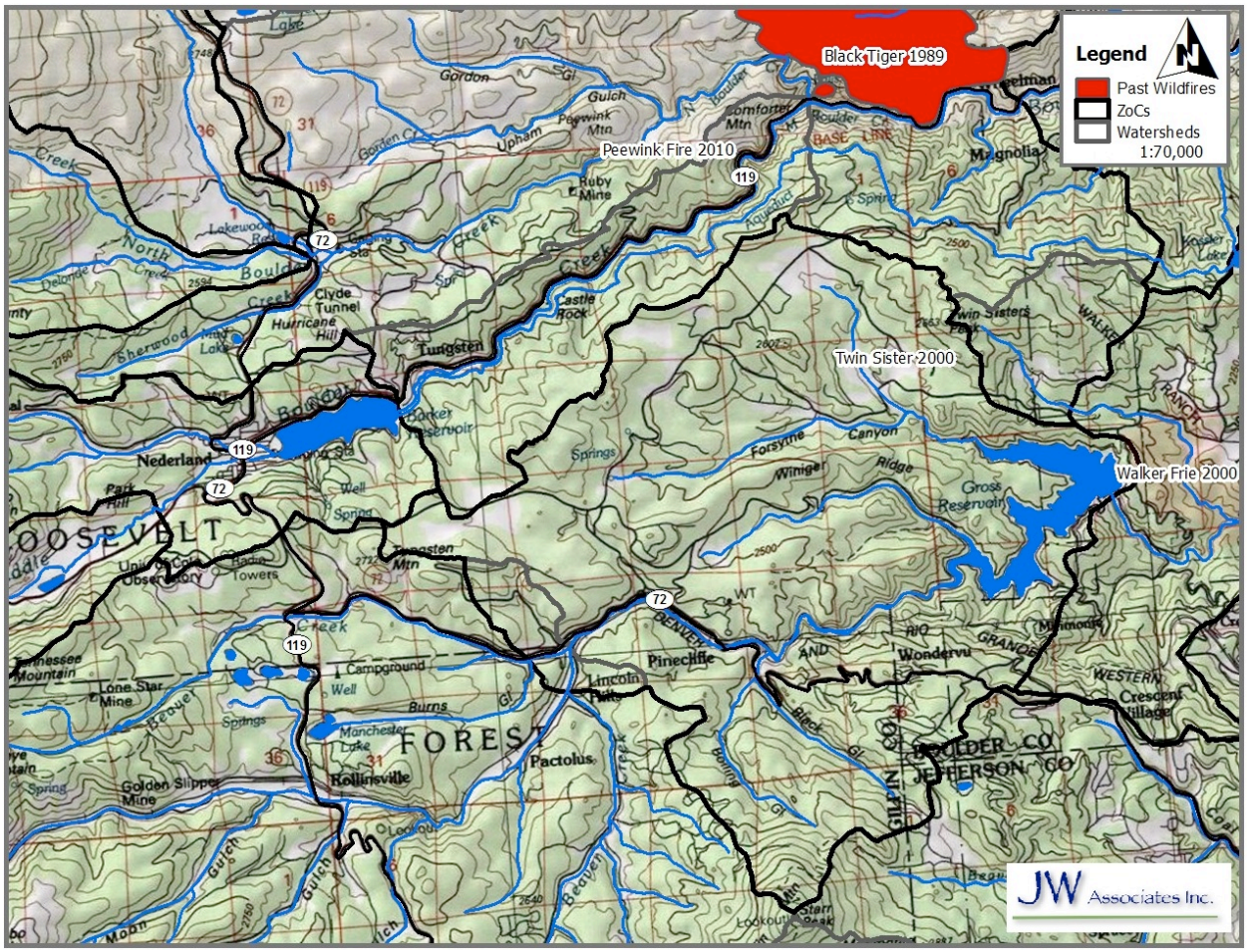


Figure 93. Gross Reservoir ZoC Past Fires

Gross Reservoir Access

There are some existing roads that provide good access to much of the Gross Reservoir ZoC (Figure 94). Some of the steeper areas do not have existing roads.

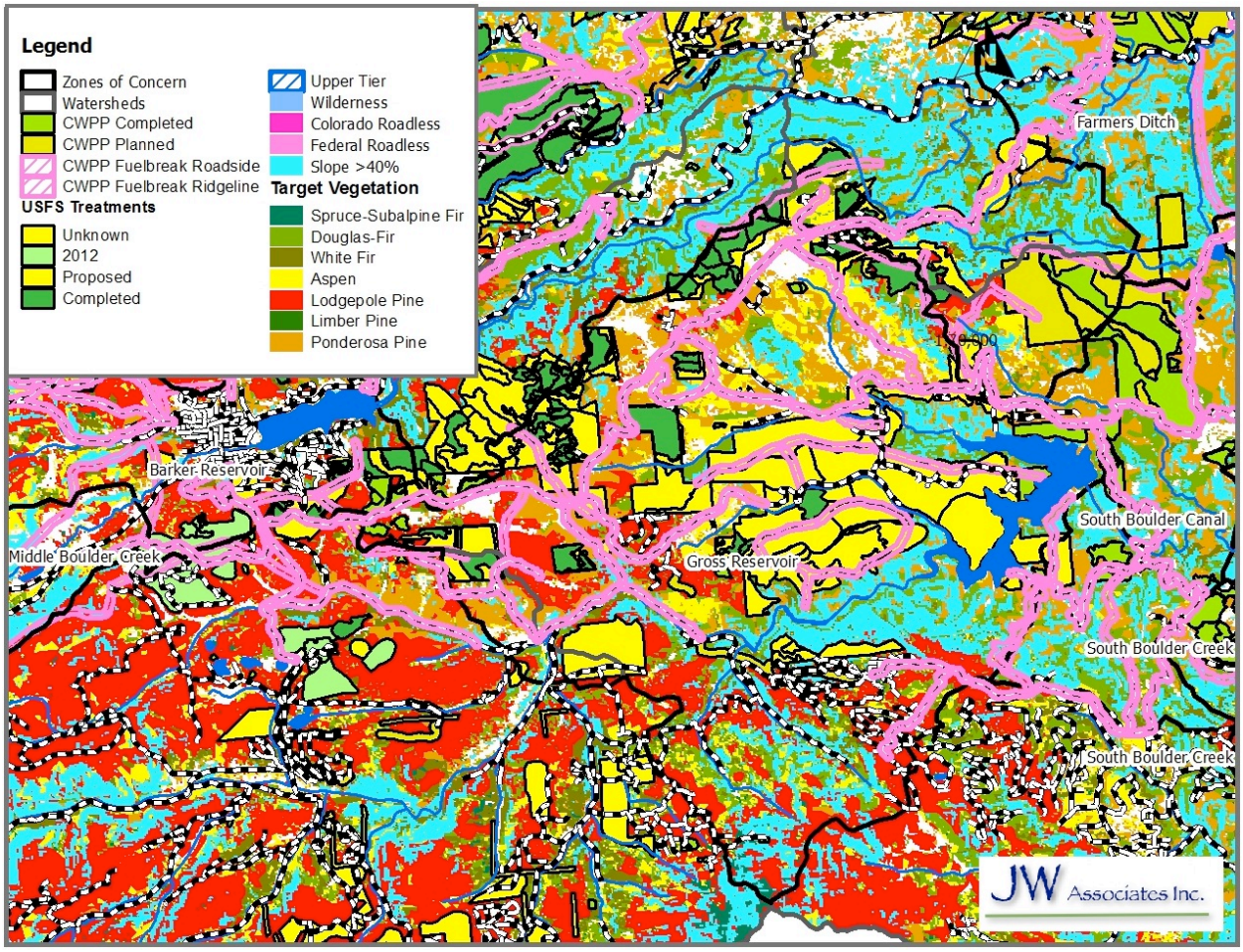


Figure 94. Gross Reservoir ZoC Opportunities

Gross Reservoir Opportunities

This watershed and ZoC has been identified as a high priority treatment area for Boulder County and Denver Water. The well-roaded and operable land west of the reservoir provides good opportunities for management. Figure 94 and the Boulder County CWPP show a complicated mix of planned and completed treatments. In spite of steep slopes near the reservoir, Denver Water and the Colorado State Forest Service have completed many hazardous fuels reduction treatments on Denver Water lands. There are many acres of forest treatments proposed in the Forsythe EA by the US Forest Service.

East of Gross Reservoir, thinning of forests to low densities is evident.

At lower elevations in the ZoC treatments in forested areas 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.

At higher elevations with large amounts of lodgepole pine, focus should be placed on developing age diversity through carefully planned and located clearcuts and patchcuts. 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.

Maintain current aspen stands through protection, and where necessary, regeneration harvests. Where ponderosa pine exists, conduct restorations harvests and attempt to expand this species by favoring its retention when thinning mixed species stands. In all areas, maintaining existing openings can be a great aid in reducing wildfire intensities and as locations from which to stage defensive suppression actions.

REFERENCES

Cannon, S.H. and S.L. Reneau. 2000. Conditions for generation of fire-related debris flows, Capulin Canyon, New Mexico. Earth Surface Processes and Landforms 25: 1103-1121.

Colorado State Forest Service. 2009. Potential Effects on Fire Behavior in Mountain Pine Beetle-Infested Areas. Unpublished report. June 17, 2009

Federal Geographic Data Committee. 2004. Draft Federal Standards for Delineation of Hydrologic Unit Boundaries, Version 2. Available at: ftp://ftp-fc.sc.egov.usda.gov/NCGC/products/watershed/hu-standards.pdf

Front Range Watershed Protection Data Refinement Work Group. 2009. Protecting Critical Watersheds in Colorado from Wildfire: A Technical Approach to Watershed Assessment and Prioritization.

Hungerford, R.D., M.G. Harrington, W.H. Frandsen, K.C. Ryan, and G.J. Niehoff. 1991. Influence of Fire on Factors that Affect Site Productivity. In: Neuenschwander, L.F., and A.E. Harvey. Comps. Management and Productivity of Western-Montane Forest Soils. General Technical Report INT-280. U.S. Dept. of Agriculture, Forest Service, Intermountain Research Station. Ogden, UT. pp 32–50.

Ice, G.G. 1985. Catalog of landslide inventories for the Northwest. Tech. Bull. 456. New York: National Council of the Paper Industry for Air and Stream Improvement. 78 p.

JEM. 2008. Mountain Pine Beetle: From Lessons Learned to Community-Based Solutions Conference Proceedings. June 10–11, 2008. University of Northern British Columbia, Prince George, B.C. JEM—Volume 9, Number 3. 2008. Forrex Forum for Research and Extension in Natural Resources Society, Kamloops, British Columbia, Canada.

Knight, D. 1987. Parasites, Lightning, and the Vegetation Mosaic in Wilderness Landscapes. Pages 59-83 in M. G. Turner, editor. Landscape Heterogeneity and Disturbance. Springer-Verlag, New York, N.Y.

Megan, W., and W. Kidd. 1972. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. Journal of Forestry 70:136-41.

Melton, M.A. 1957. An analysis of the relations among elements of climate, surface properties, and geomorphology. Technical Report 11. Department of Geology, Columbia University. New York, NY. p. 102.

Moody, J.A. and D.A. Martin. 2001. Initial hydrologic and geomorphic response following a wildfire in the Colorado Front Range. Earth Surface Processes and Landforms 26: 1049-1070.

Moody, J.A., D.A. Martin, S.L. Haire, D.A. Kinner. 2008. Linking runoff response to burn severity after a wildfire. Hydrological Processes 22: 2063-2074.

Neary, D.G.; Ryan, K.C.; DeBano, L.F. (eds) 2005. (revised 2008). Wildland fire in ecosystems: effects of fire on soils and water. General Technical Report RMRS-GTR-42-vol.4. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 250 p. Available at: http://www.fs.fed.us/rm/pubs/rmrs_gtr042_4.pdf

Page, W. and M.J. Jenkins. 2007. Predicted Fire Behavior in Selected Mountain Pine Beetle–Infested Lodgepole Pine. Forest Science 53(6) 2007.

Robichaud, P.R., and T.A. Waldrop. 1994. A Comparison of surface runoff and sediment yields from low- and high-intensity prescribed burns. Water Resources Bulletin 30(1):27-34.

Schmid, J.M. and G.D. Amman. 1992. Dendroctonus beetles and old-growth forests in the Rockies, pp. 51-59. In: Kaufmann, M.R., W.H. Moir, and R.L. Bassett (tech. coord.). Old-growth Forests in the Southwest and Rocky Mountain Regions, Proceedings of a Workshop. USDA For. Ser., Rocky Mountain For. and Range Exp. Stn. Gen. Tech. Rep. RM-213, 201 p. Ft. Collins, CO.

Schroeder, D. and C. Mooney. 2009. Fire Behaviour in Simulated Mountain Pine Beetle Attacked Stands Interim Report. FPInnovations – Feric Division, February 2009

Soto, B., R. Basanta, E. Benito, R. Perez, and F. Diaz-Fierros. 1994. Runoff and erosion from burnt soils in Northwest Spain. In: Sala, M., and J.L. Rubio (eds). Soil Erosion and Degradation as a Consequence of Forest Fires: Proceedings. Barcelona, Spain: 91–98.

Swanson, F.J.; Benda, L.E.; Duncan, S.H.; Grant, G.E.; Megahan, W.F.; Reid, L.M.; Ziemer, R.R. 1987. Mass failures and other processes of sediment production in Pacific Northwest forest landscapes. In: Salo, Ernest O.; Cundy, Terrance W., eds. Streamside management: forestry and fishery interactions: Proceedings of a symposium; 1986 February 12-14; Seattle. Contribution No. 57. Seattle: University of Washington, Institute of Forest Resources: 9-38. Chapter 2.

USDA Natural Resource Conservation Service. 1997. National Forestry Manual, title 190. Washington, D.C., Government Printing Office, June 1997.

Wells, C.G., R.E. Campbell, L.F. DeBano, C.E. Lewis, R.L. Fredriksen, E.C. Franklin, R.C. Froelich, and P.H. Dunn. 1979. Effects of Fire on Soil, a State-of-Knowledge Review. General Technical Report WO-7. U.S. Department of Agriculture, Forest Service. Washington, DC. p 34.

APPENDIX A

LIST OF SAINT VRAIN WATERSHED STAKEHOLDERS

Table A-1. Saint Vrain Watershed Stakeholders List

Organization	Last	First	Phone	email
Boulder County	Golden	Scott	303.678.6209	sgolden@bouldercounty.org
Boulder County	Webster	Jim	720.564.2600	jbwebster@bouldercounty.org
Boulder County	Davis	Megan	303.441.3562	medavis@bouldercounty.org
Boulder County Parks & Open Space	Koopmann	Rich	303.678.6270	rkoopmann@bouldercounty.org
Boulder County Parks & Open Space	Strenge	Ernst	303.678.6269	estrenge@bouldercounty.org
Boulder Creek Watershed Initiative	Cowart	Jim	303.324.4272	jcowart@envirogroup.com
City of Boulder	Wind	Michelle	303.413.7405	windm@bouldercolorado.gov
City of Boulder	Shelley	Jim	303.413.7402	Shelleyj@bouldercolorado.gov
City of Boulder	Hutton	Kim	303.441.3115	Huttonk@bouldercolorado.gov
City of Boulder	Creek	Jim	303.258.3259	creekj@bouldercolorado.gov
City of Boulder	Linenfelser	Bret	303.413.7355	linenfelserb@bouldercolorado.gov
City of Lafayette	Dallam	Brad	303.665.5586	bradd@cityoflafayette.com
City of Longmont	Boden	Kevin	303.774.4516	kevin.boden@ci.longmont.co.us
City of Longmont	Wolford	Dan	303.774.4691	dan.wolford@ci.longmont.co.us
City of Longmont	Youngberg	Cal	303.651.8399	Cal.Youngberg@ci.longmont.co.us
City of Longmont	Fisher	Dennis	303.823.6060	dennis.fisher@ci.longmont.co.us
City of Louisville	Mathes	Dan	303.335.4604	danm@louisvilleco.gov
Colorado Rural Water & James Creek Watershed Initiative	Williams	Colleen	303.449.2621	colleen@jimtown.org
Colorado State Forest Service	Owen	Allen	303.823.5774	alowen@lamar.colostate.edu
Denver Water	Kennedy	Don	303.628.6528	don.Kennedy@denverwater.org
Forest Restoration Solutions	Dennis	Chuck	303.659.4381	cdennis@lamar.colostate.edu
Left Hand Ditch Company	Plummer	Terry	303.652.9965	lefthandditch@msn.com
Left Hand Water District	Smith	Chris	303.530.4200	chrissmith@lefthandwater.org
Left Hand Water District	Schmidt	Hank	303.530.4200	hank@lefthandwater.org
Lefthand Watershed Oversight Group	Patterson	Glen	303.747.2089	
Lefthand Watershed Oversight Group	Williams	Lee	303.772.4060	
Lefthand Watershed Oversight Group	Peterson	Kathy	303.530.4200	kapeterson@lefthandwater.org
St. Vrain and Left Hand Water Conservancy District	Cronin	Sean	303.772.4060	sean.cronin@svlhwcd.org
The Nature Conservancy	Lewis	Page		paige_lewis@tnc.org
Town of Erie	Palmer	Wendi	303.926.2875	wpalmer@erieco.gov
Town of Erie	Behlen	Gary	303.926.2871	gbehlen@erieco.gov
Town of Nederland/NFPD	Turner	Jack		jackdturner@gmail.com
Town of Ward	Lawrence	Pete		pblh2o@netzero.com
Trout Unlimited	Luneau	Barbara		barbaraluneau@gmail.com
US Forest Service	Clark	Sylvia	303.541.2505	sgclark@fs.fed.us
US Forest Service	Harper	Claire	303.275.5178	claireharper@fs.fed.us
US Forest Service	Schroder	Eric	303.541.2538	eschroder@fs.fed.us
US Forest Service	Gibbs	Hal	970.295.6630	hdgibbs@fs.fed.us
US Forest Service	Hutchinson	Cody	303.541.2512	crhutchinson@fs.fed.us
US Forest Service	Chambers	Carl	970.295.6633	cchambers@fs.fed.us
US Forest Service	Zimlinghaus	Kevin		kzimlinghaus@fs.fed.us
US Forest Service - San Carlos RD	Park	Dave	719.269.8542	dpark@fs.fed.us
Xcel Energy	Rhodes	Randy	720.497.2123	Randy.rhodes@xcelenergy.org

APPENDIX B

SAINT VRAIN 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
Saint Vrain	12	25
Saint Vrain	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 SAINT VRAIN WATERSHED ASSESSMENT RESULTS

Table C-1. Saint Vrain Watershed Wildfire Hazard Ranking

Sixth-level Watershed Name	Watershed Area (acres)	Wildfire Hazard Calculation	Wildfire Hazard Rank
Rock Creek	9,428	80.4%	5.5
Outlet North Saint Vrain Creek	31,351	78.5%	5.3
Outlet South Saint Vrain Creek	14,358	76.4%	5.1
Boulder Creek Canyon	9,783	75.6%	5.1
Upper Coal Creek	16,423	69.9%	4.5
Lower South Boulder Creek	14,534	68.8%	4.4
Middle Left Hand Creek	10,290	68.1%	4.4
Upper South Boulder Creek	26,124	67.5%	4.3
Middle South Boulder Creek	25,637	64.2%	4.0
Cabin Creek	14,498	63.8%	4.0
Fourmile Creek	15,528	63.1%	3.9
Headwaters South Boulder Creek	19,430	62.7%	3.9
Fourmile Canyon Creek	6,495	62.3%	3.8
Upper Left Hand Creek	14,839	61.2%	3.7
Headwaters South Saint Vrain Creek	21,839	61.2%	3.7
James Creek (1)	11,917	60.6%	3.7
North Boulder Creek	28,612	58.4%	3.5
Middle Saint Vrain Creek	20,944	58.3%	3.5
Indian Mountain-Saint Vrain Creek	14,972	58.0%	3.4
Middle Boulder Creek	28,334	56.4%	3.3
Headwaters North Saint Vrain Creek	24,238	52.3%	2.9
Dry Creek-Boulder Creek	14,059	40.7%	1.9
Middle Coal Creek	19,799	38.4%	1.6
Boulder Reservoir	21,482	35.6%	1.4
Dry Creek	8,958	34.3%	1.3
City of Boulder-Boulder Creek	18,556	34.2%	1.3
Lower Left Hand Creek	9,484	28.6%	0.8
McIntosh Lake-Saint Vrain Creek	28,617	25.8%	0.5
Totals	500,529		

Table C-2. Saint Vrain Watershed Ruggedness Ranking[1, 2]

Sixth-level Watershed Name	Maximum Elevation	Minimum Elevation	Difference Elevation	Ruggedness	Ruggedness Rank
Cabin Creek	13,556	7,629	5,927	0.2359	5.5
Fourmile Creek	11,467	5,766	5,701	0.2192	5.1
Headwaters South Saint Vrain Creek	13,369	6,973	6,396	0.2074	4.8
Upper Left Hand Creek	11,513	6,317	5,196	0.2044	4.7
Headwaters North Saint Vrain Creek	14,252	7,718	6,534	0.2011	4.7
Middle Saint Vrain Creek	13,117	7,091	6,026	0.1995	4.6
Rock Creek	11,631	7,649	3,982	0.1965	4.6
Upper Coal Creek	10,496	5,455	5,041	0.1885	4.4
Fourmile Canyon Creek	8,295	5,169	3,126	0.1858	4.3
Middle Boulder Creek	13,389	6,918	6,471	0.1842	4.3
North Boulder Creek	13,504	7,108	6,396	0.1812	4.2
James Creek (1)	10,047	6,416	3,631	0.1594	3.7
Headwaters South Boulder Creek	13,291	8,843	4,448	0.1529	3.5
Boulder Creek Canyon	8,863	5,724	3,139	0.1521	3.5
Lower South Boulder Creek	8,731	5,150	3,581	0.1423	3.3
Middle Left Hand Creek	8,554	5,648	2,906	0.1373	3.1
Outlet South Saint Vrain Creek	8,574	5,320	3,254	0.1301	3.0
Middle South Boulder Creek	10,384	6,117	4,267	0.1277	2.9
Upper South Boulder Creek[2]	10,886	8,082	2,804	0.1176	2.7
City of Boulder-Boulder Creek	8,220	5,159	3,061	0.1077	2.4
Outlet North Saint Vrain Creek	9,243	5,346	3,897	0.1055	2.4
Lower Left Hand Creek	6,271	4,923	1,348	0.0663	1.5
Indian Mountain-Saint Vrain Creek	6,754	5,071	1,683	0.0659	1.4
Boulder Reservoir	6,665	4,887	1,778	0.0581	1.3
McIntosh Lake-Saint Vrain Creek	6,803	4,930	1,873	0.0530	1.1
Middle Coal Creek	6,334	5,120	1,214	0.0413	0.9
Dry Creek	5,596	4,940	656	0.0332	0.7
Dry Creek-Boulder Creek	5,707	5,061	646	0.0261	0.5

[1] Ruggedness is based on Melton (1957)

[2] These watersheds were manually adjusted because they do not accurately reflect the ruggedness in those watersheds. The original values were; South Boulder Creek (0.0831)

Table C-3. Saint Vrain Watershed Road Density Ranking[3]

Sixth-level Watershed Name	Roads (miles)	Roads Adjusted (miles)	Watershed Area (sq. mi.)	Road density (miles per sq. mi.)	Road Density Rank
Fourmile Canyon Creek[3]	14.3	7.0	10.15	0.69	5.5
Upper Coal Creek	16.5	16.5	25.66	0.64	5.1
Upper South Boulder Creek	26.0	26.0	40.82	0.64	5.1
Fourmile Creek	15.4	15.4	24.26	0.63	5.1
Boulder Creek Canyon	9.4	9.4	15.29	0.61	4.9
Upper Left Hand Creek	12.5	12.5	23.19	0.54	4.4
Middle South Boulder Creek	17.9	17.9	40.06	0.45	3.7
James Creek (1)	7.2	7.2	18.62	0.39	3.2
Middle Boulder Creek	16.6	16.6	44.27	0.37	3.1
Cabin Creek	8.1	8.1	22.65	0.36	3.0
Rock Creek	5.1	5.1	14.73	0.35	2.9
Outlet North Saint Vrain Creek	16.2	16.2	48.99	0.33	2.8
Middle Left Hand Creek	5.3	5.3	16.08	0.33	2.8
North Boulder Creek	13.6	13.6	44.71	0.30	2.6
Outlet South Saint Vrain Creek	6.4	6.4	22.43	0.29	2.5
Headwaters South Boulder Creek	8.1	8.1	30.36	0.27	2.3
Lower South Boulder Creek[3]	12.6	6.0	22.71	0.26	2.3
Middle Saint Vrain Creek	7.1	7.1	32.73	0.22	2.0
Headwaters South Saint Vrain Creek	6.9	6.9	34.12	0.20	1.9
Headwaters North Saint Vrain Creek	3.2	3.2	37.87	0.09	1.0
Dry Creek[3]	18.7	1.0	14.00	0.07	0.9
Lower Left Hand Creek[3]	20.5	1.0	14.82	0.07	0.8
Dry Creek-Boulder Creek[3]	26.1	1.0	21.97	0.05	0.7
Indian Mountain-Saint Vrain Creek[3]	11.0	1.0	23.39	0.04	0.7
City of Boulder-Boulder Creek[3]	89.4	1.0	28.99	0.03	0.6
Middle Coal Creek[3]	65.0	1.0	30.94	0.03	0.6
Boulder Reservoir[3]	36.1	1.0	33.57	0.03	0.6
McIntosh Lake-Saint Vrain Creek[3]	72.8	1.0	44.71	0.02	0.5
Totals	568.0	222.5	782.08	0.28	

[3] The road density was adjusted based upon the procedure discussed in the report (p. 11).

Table C-4. Saint Vrain Watershed Flooding/Debris Flow Hazard Ranking

Sixth-level Watershed Name	Ruggedness Ranking	Road Density Ranking	Combined Numeric Rank	Combined Ranking
Fourmile Creek	5.1	5.1	15.29	5.5
Fourmile Canyon Creek	4.3	5.5	14.12	5.1
Cabin Creek	5.5	3.0	14.00	5.0
Upper Coal Creek	4.4	5.1	13.89	5.0
Upper Left Hand Creek	4.7	4.4	13.87	5.0
Rock Creek	4.6	2.9	12.06	4.3
Boulder Creek Canyon	3.5	4.9	11.92	4.3
Middle Boulder Creek	4.3	3.1	11.67	4.2
Headwaters South Saint Vrain Creek	4.8	1.9	11.50	4.1
Middle Saint Vrain Creek	4.6	2.0	11.23	4.0
North Boulder Creek	4.2	2.6	11.00	3.9
James Creek (1)	3.7	3.2	10.58	3.8
Upper South Boulder Creek	1.9	5.1	8.82	3.1
Headwaters North Saint Vrain Creek	4.7	1.0	10.32	3.7
Middle South Boulder Creek	2.9	3.7	9.52	3.4
Headwaters South Boulder Creek	3.5	2.3	9.38	3.3
Middle Left Hand Creek	3.1	2.8	9.11	3.2
Lower South Boulder Creek	3.3	2.3	8.85	3.1
Outlet South Saint Vrain Creek	3.0	2.5	8.43	3.0
Outlet North Saint Vrain Creek	2.4	2.8	7.60	2.7
City of Boulder-Boulder Creek	2.4	0.6	5.48	1.9
Lower Left Hand Creek	1.5	0.8	3.76	1.3
Indian Mountain-Saint Vrain Creek	1.4	0.7	3.55	1.2
Boulder Reservoir	1.3	0.6	3.08	1.0
McIntosh Lake-Saint Vrain Creek	1.1	0.5	2.78	0.9
Middle Coal Creek	0.9	0.6	2.30	0.7
Dry Creek	0.7	0.9	2.21	0.7
Dry Creek-Boulder Creek	0.5	0.7	1.67	0.5

Table C-5. Saint Vrain Watershed Soil Erodibility Ranking[4,5]

Sixth-level Watershed Name	Severe (%)	Very Severe (%)	Soil Erodibility Value	Soil Erodibility Rank
City of Boulder-Boulder Creek[5]	8.0%	71.1%	0.330	5.5
Indian Mountain-Saint Vrain Creek[5]	13.7%	66.5%	0.330	5.5
Upper Left Hand Creek[5]	66.1%	0.1%	0.330	5.5
Middle Left Hand Creek[5]	26.1%	10.6%	0.330	5.5
Boulder Creek Canyon[5]	49.6%	0.0%	0.330	5.5
Middle South Boulder Creek	17.0%	7.7%	0.325	5.4
Upper Coal Creek	16.4%	6.2%	0.288	4.9
Lower South Boulder Creek	16.2%	6.3%	0.287	4.9
Fourmile Canyon Creek	16.0%	5.7%	0.274	4.7
Fourmile Creek	25.2%	0.2%	0.257	4.4
Outlet South Saint Vrain Creek	22.4%	0.4%	0.233	4.0
Outlet North Saint Vrain Creek	13.9%	2.1%	0.181	3.2
James Creek (1)	15.8%	0.0%	0.158	2.9
Upper South Boulder Creek	8.4%	3.3%	0.151	2.8
Middle Boulder Creek	5.1%	2.8%	0.108	2.1
Lower Left Hand Creek	0.7%	2.6%	0.059	1.4
Boulder Reservoir	1.9%	1.7%	0.053	1.3
North Boulder Creek	2.4%	0.6%	0.036	1.0
McIntosh Lake-Saint Vrain Creek	1.4%	0.5%	0.023	0.9
Middle Coal Creek	1.5%	0.0%	0.015	0.7
Middle Saint Vrain Creek	1.3%	0.0%	0.013	0.7
Dry Creek	1.2%	0.0%	0.013	0.7
Headwaters South Saint Vrain Creek	0.6%	0.0%	0.006	0.6
Dry Creek-Boulder Creek	0.1%	0.0%	0.001	0.5
Rock Creek	0.0%	0.0%	0.000	0.5
Headwaters North Saint Vrain Creek	0.0%	0.0%	0.000	0.5
Cabin Creek	0.0%	0.0%	0.000	0.5
Headwaters South Boulder Creek	0.0%	0.0%	0.000	0.5

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

[5] These watersheds were skewing the categorization because of their high soil erodibility values and were manually given a score slightly higher than the next highest score.

Table C-6. Saint Vrain Watershed Composite Hazard Ranking

Sixth-level Watershed Name	Wildfire Hazard Rank	Flooding/ Debris Flow Rank	Soil Erodibility Rank	Composite Hazard Rank
Boulder Creek Canyon	5.1	4.3	5.5	5.5
Upper Coal Creek	4.5	5.0	4.9	5.3
Upper Left Hand Creek	3.7	5.0	5.5	5.3
Fourmile Creek	3.9	5.5	4.4	5.1
Fourmile Canyon Creek	3.8	5.1	4.7	5.0
Middle Left Hand Creek	4.4	3.2	5.5	4.8
Middle South Boulder Creek	4.0	3.4	5.4	4.7
Lower South Boulder Creek	4.4	3.1	4.9	4.5
Outlet South Saint Vrain Creek	5.1	3.0	4.0	4.4
Outlet North Saint Vrain Creek	5.3	2.7	3.2	4.1
Upper South Boulder Creek	4.3	3.1	2.8	3.7
Rock Creek	5.5	4.3	0.5	3.7
James Creek (1)	3.7	3.8	2.9	3.7
Indian Mountain-Saint Vrain Creek	3.4	1.2	5.5	3.6
Middle Boulder Creek	3.3	4.2	2.1	3.4
Cabin Creek	4.0	5.0	0.5	3.4
City of Boulder-Boulder Creek	1.3	1.9	5.5	3.0
North Boulder Creek	3.5	3.9	1.0	3.0
Headwaters South Saint Vrain Creek	3.7	4.1	0.6	3.0
Middle Saint Vrain Creek	3.5	4.0	0.7	2.9
Headwaters South Boulder Creek	3.9	3.3	0.5	2.7
Headwaters North Saint Vrain Creek	2.9	3.7	0.5	2.4
Boulder Reservoir	1.4	1.0	1.3	1.1
Lower Left Hand Creek	0.8	1.3	1.4	1.0
Middle Coal Creek	1.6	0.7	0.7	0.8
Dry Creek-Boulder Creek	1.9	0.5	0.5	0.7
Dry Creek	1.3	0.7	0.7	0.7
McIntosh Lake-Saint Vrain Creek	0.5	0.9	0.9	0.5

Table C-7. Saint Vrain Watershed Water Supply Ranking

Sixth-level Watershed Name	Sources & Diversions	Reservoirs	Water Ranking
Headwaters South Saint Vrain Creek	1		1
Middle Saint Vrain Creek	0		0
Outlet South Saint Vrain Creek	1		1
Rock Creek	1		1
Headwaters North Saint Vrain Creek	1		1
Cabin Creek	1		1
Outlet North Saint Vrain Creek	1	1	1
James Creek (1)	1		1
Upper Left Hand Creek	0		0
Middle Left Hand Creek	1		1
Lower Left Hand Creek	1		1
North Boulder Creek	1		1
Middle Boulder Creek	1	1	1
Fourmile Creek	1		1
Boulder Creek Canyon	0		0
Fourmile Canyon Creek	0		0
City of Boulder-Boulder Creek	1		1
Headwaters South Boulder Creek	0		0
Upper South Boulder Creek	0		0
Middle South Boulder Creek	1	1	1
Lower South Boulder Creek	1		1
Dry Creek-Boulder Creek	0		0
Upper Coal Creek	0		0
Middle Coal Creek	1		1
Indian Mountain-Saint Vrain Creek	1		1
Dry Creek	0		0
McIntosh Lake-Saint Vrain Creek	1		1
Boulder Reservoir	0	1	1

Table C-8. Saint Vrain Final Watershed Ranking

Sixth-level Watershed Name	Wildfire Hazard	Flooding/ Debris Flow	Soil Erodibility	Composite	Water Supply	Final Ranking
Fourmile Creek	3.9	5.5	4.4	5.1	1	5.5
Middle Left Hand Creek	4.4	3.2	5.5	4.8	1	5.2
Middle South Boulder Creek	4.0	3.4	5.4	4.7	1	5.1
Lower South Boulder Creek	4.4	3.1	4.9	4.5	1	5.0
Boulder Creek Canyon	5.1	4.3	5.5	5.5	0	4.9
Outlet South Saint Vrain Creek	5.1	3.0	4.0	4.4	1	4.8
Upper Coal Creek	4.5	5.0	4.9	5.3	0	4.7
Upper Left Hand Creek	3.7	5.0	5.5	5.3	0	4.7
Outlet North Saint Vrain Creek	5.3	2.7	3.2	4.1	1	4.5
Fourmile Canyon Creek	3.8	5.1	4.7	5.0	0	4.4
James Creek (1)	3.7	3.8	2.9	3.7	1	4.1
Rock Creek	5.5	4.3	0.5	3.7	1	4.1
Indian Mountain-Saint Vrain Creek	3.4	1.2	5.5	3.6	1	4.1
Middle Boulder Creek	3.3	4.2	2.1	3.4	1	3.9
Cabin Creek	4.0	5.0	0.5	3.4	1	3.8
City of Boulder-Boulder Creek	1.3	1.9	5.5	3.0	1	3.5
North Boulder Creek	3.5	3.9	1.0	3.0	1	3.4
Headwaters South Saint Vrain Creek	3.7	4.1	0.6	3.0	1	3.4
Upper South Boulder Creek	4.3	3.1	2.8	3.7	0	3.1
Headwaters North Saint Vrain Creek	2.9	3.7	0.5	2.4	1	2.9
Middle Saint Vrain Creek	3.5	4.0	0.7	2.9	0	2.3
Headwaters South Boulder Creek	3.9	3.3	0.5	2.7	0	2.1
Boulder Reservoir	1.4	1.0	1.3	1.1	1	1.6
Lower Left Hand Creek	0.8	1.3	1.4	1.0	1	1.4
Middle Coal Creek	1.6	0.7	0.7	0.8	1	1.3
McIntosh Lake-Saint Vrain Creek	0.5	0.9	0.9	0.5	1	1.0
Dry Creek-Boulder Creek	1.9	0.5	0.5	0.7	0	0.3
Dry Creek	1.3	0.7	0.7	0.7	0	0.2