Appendix A

Upper South Platte Watershed Assessment Test Case

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Introduction

One of the tasks of the Front Range Watershed Protection Data Refinement Work Group was to apply the watershed assessment approach to a test case to help adapt and refine the approach. The Work Group chose the Upper South Platte Watershed for the following reasons;

- 1. It is well known and studied.
- 2. There is a previous prioritization to which results can be compared.
- 3. Some soils data challenges exist.

Background

The Upper South Platte Watershed provides the City of Denver with 75 percent of its drinking water supply. Because of its close proximity to Denver, it provides easy accessibility to fishing, hiking and other outdoor experiences. The watershed also is home to portions of two wilderness areas (Lost Creek and Mt. Evans). Portions of the South Platte River are designated as a gold medal trout fishery.

In 1996, an intense wildfire in the Buffalo Creek drainage resulted in the loss of several houses and forest cover on nearly 12,000 acres. This fire was a wind-driven (up to 70 miles per hour) crown fire that burned more than 10,000 acres in one day. Two large summer storms in the burn area caused catastrophic erosion and deposition of sediment in the watershed's streams, and tragically contributed to two human deaths. The Denver Water Board and the City of Aurora are planning extensive dredging of Strontia Springs Reservoir due to sediment from the Buffalo Creek Fire that was transported and deposited into the water-supply reservoir.

In 2000, the Hi Meadow Fire burned more than 10,000 acres near the Buffalo Creek burn area. Unlike the Buffalo Creek Fire, this fire burned in a mosaic pattern, although many areas experienced intense crown fire. Some erosion and sedimentation problems were associated with runoff following the fire.

In 2002, three wildfires occurred in the Upper South Platte Watershed. The Snaking Fire burned about 2,500 acres near Bailey. Although relatively small, the fire lead to evacuations in the Town of Bailey and surrounding populated areas. The Schoonover Fire burned nearly 3,500 acres near Deckers and the Hayman Fire, the largest fire in Colorado history, burned 137,000 acres. The Hayman Fire burned the entire area around Cheesman Lake, which has experienced substantial erosion and deposition as a result.

Watershed Characterization

The Upper South Platte Watershed is a fourth-level watershed that is approximately 649,694 acres in area and contains 22 sixth-level watersheds (Table A-1). The sixth-level watersheds in the Upper South Platte Watershed are shown on Figure A-1.

WATERSHED NAME	HYDROLOGIC UNIT CODE (HUC)	WATERSHED AREA (ACRES)
Bailey	101900020303	46,464
Buffalo Creek	101900020404	30,861
Cheesman	101900020101	39,603
Craig Creek	101900020304	21,644
Deer Creek	101900020402	27,150
Disappearing Creek	101900020103	11,943
Elk Creek	101900020403	40,430
Fourmile/Deckers	101900020105	10,963
Geneva Creek	101900020302	49,679
Goose Creek	101900020104	19,382
Lost Creek	101900020102	28,204
Lower Trout Creek	101900020804	31,980
Lowest North Fork	101900020405	29,900
Manitou Park	101900020803	28,043
North Fork Headwaters	101900020301	31,446
Pine-Rowland	101900020401	27,092
Rule Creek	101900020801	12,726
South Platte Canyon	101900020501	24,016
Upper Trout Creek	101900020802	18,585
Waterton/Deckers	101900020107	51,673
West Creek	101900020805	44,224
Wigwam Creek	101900020106	23,686

TABLE A-1. SIXTH-LEVEL WATERSHEDS IN THE UPPER SOUTH PLATTE WATERSHED



FIGURE A-1. SIXTH-LEVEL WATERSHEDS IN THE UPPER SOUTH PLATTE WATERSHED

Watershed Assessment

The Upper South Platte Watershed Assessment is divided into four components that focus on the technical aspects of the issues that have been defined as most critical to the protection of watershed conditions. The watershed's ability to deliver sediments following catastrophic wildfire depends on forest and soil conditions, and the physical configuration of those watersheds. These conditions then are evaluated relative to the locations of water uses.

COMPONENT 1 - WILDFIRE HAZARD

Forest conditions that are of concern for the assessments are wildfire risk or hazard based on existing forest conditions. In 2007, the Pinchot Institute for Conservation evaluated the wildfire hazard for the 10 Front Range counties. The wildfire hazard assessment presented in the report was determined by using the following formula (Colorado State Forest Service 2002).

Wildfire Hazard = Fuel Hazard*0.40 + Disturbance Regime*0.35 + Aspect*0.10 + Slope *0.15

The analysis presented in the Pinchot Institute for Conservation Report (2007) was used to assess the wildfire hazard for the Upper South Platte Watershed. Because large portions of the area are covered by Category 3, Categories 4 and 5 were used as indicators of high and severe wildfire hazard, respectively. Sixth-level watersheds were rated for wildfire hazard based on the following formula.

Wildfire Hazard =

Area in Category 4 * 1 + Area in Category 5 * 2

Watershed Area

The results of the wildfire hazard ranking and categorization are shown in Table A-2 and Figure A-2.

WATERSHED NAME	WILDFIRE HAZARD CALCULATION	WILDFIRE HAZARD Ranking
Bailey	70.77%	Moderate-High
Buffalo Creek	90.69%	High
Cheesman	93.75%	Very High
Craig Creek	40.80%	Moderate
Deer Creek	46.02%	Moderate
Disappearing Creek	50.52%	Moderate
Elk Creek	73.19%	High
Fourmile/Deckers	101.93%	Very High
Geneva Creek	22.41%	Low
Goose Creek	81.91%	High
Lost Creek	19.63%	Low
Lower Trout Creek	101.16%	Very High
Lowest North Fork	94.88%	Very High
Manitou Park	87.94%	High
North Fork Headwaters	24.26%	Low
Pine-Rowland	100.68%	Very High
Rule Creek	53.47%	Moderate-High
South Platte Canyon	101.87%	Very High
Upper Trout Creek	68.54%	Moderate-High
Waterton/Deckers	101.63%	Very High
West Creek	93.81%	Very High
Wigwam Creek	90.71%	High

TABLE A-2. UPPER SOUTH PLATTE WATERSHED WILDFIRE HAZARD RANKING



FIGURE A-2. UPPER SOUTH PLATTE WATERSHED WILDFIRE HAZARD RANKING MAP

Component 2 - Flooding or Debris Flow Risk

Slope

Watershed steepness or ruggedness can be 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) defines ruggedness, R, as;

 $R=H_bA_b\text{-}0.5$

where A_b is watershed area and H_b is watershed height measured from the point of highest elevation along the watershed divide to the outlet. These data were extracted from GIS data and the calculations are presented in Table A-3 along with the ranking for slope. A slope ranking map is presented as Figure A-3.

TABLE A-3. UPPER SOUTH PLATTE WATERSHED SLOPE RANKING

WATERSHED NAME	RUGGEDNESS CALCULATION	SLOPE HAZARD Ranking	
Bailey	0.1180	Moderate-High	
Buffalo Creek	0.1606	High	
Cheesman	0.0978	Moderate	
Craig Creek	0.1565	High	
Deer Creek	0.1859	Very High	
Disappearing Creek	0.1754	High	
Elk Creek	0.1303	Moderate-High	
Fourmile/Deckers	0.1568	High	
Geneva Creek	0.1221	Moderate-High	
Goose Creek	0.1675	High	
Lost Creek	0.0794	Low	
Lower Trout Creek	0.0767	Low	
Lowest North Fork	0.0940	Moderate	
Manitou Park	0.0552	Low	
North Fork Headwaters	0.1202	Moderate-High	
Pine-Rowland	0.0782	Low	
Rule Creek	0.1149	Moderate-High	
South Platte Canyon	0.1005	Moderate	
Upper Trout Creek	0.0930	Moderate	
Waterton/Deckers	0.0722	Low	
West Creek	0.0732	Low	
Wigwam Creek	0.1554	High	



FIGURE A-3. UPPER SOUTH PLATTE WATERSHED SLOPE RANKING MAP

Road Density

Roads can convert subsurface runoff to surface runoff and then route the surface runoff to stream channels, increasing peakflows (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 will be used as an indicator of flooding risk. The U.S. Census Bureau's Tiger database was used as a consistent roads layer for the entire Upper South Platte Watershed. The Tiger database was downloaded from; http://www.census.gov/geo/www/tiger/tgrshp2007/tgrshp2007.html. The road-density data are presented in Table A-4 along with the ranking for road density. A road-density ranking map is presented as Figure A-4.

WATERSHED NAME	ROAD DENSITY (MILES/SQ. MILE)	ROAD DENSITY HAZARD RANKING
Bailey	1.3	Moderate
Buffalo Creek	0.9	Low
Cheesman	1.5	Moderate
Craig Creek	0.2	Low
Deer Creek	3.1	High
Disappearing Creek	0.0	Low
Elk Creek	3.1	High
Fourmile/Deckers	1.0	Low
Geneva Creek	0.4	Low
Goose Creek	0.9	Low
Lost Creek	1.1	Low
Lower Trout Creek	1.7	Moderate
Lowest North Fork	2.4	Moderate-High
Manitou Park	2.1	Moderate-High
North Fork Headwaters	1.2	Low
Pine-Rowland	2.9	High
Rule Creek	3.3	High
South Platte Canyon	1.0	Low
Upper Trout Creek	3.9	Very High
Waterton/Deckers	1.0	Low
West Creek	1.7	Moderate
Wigwam Creek	1.0	Low

TABLE A-4. UPPER SOUTH PLATTE WATERSHED ROAD-DENSITY RANKING



FIGURE A-4. UPPER SOUTH PLATTE WATERSHED ROAD DENSITY RANKING MAP

Flooding or Debris Flow Risk Combined Ranking

The Front Range Watershed Protection Data Refinement Work Group determined that slope should have a higher value than road density in this ranking. This determination was followed in the Upper South Platte Watershed Assessment Test Case with ruggedness, or slope, having twice the value as road density in the combined ranking. The individual rankings and the combined flooding or debris flow risk rankings are presented in Table A-5, and the combined ranking map is presented as Figure A-5.

	SLOPE HAZARD	ROAD DENSITY	FLOODING OR Debris flow	
WATERSHED NAME	RANKING	HAZARD RANKING	HAZARD RANKING	
Bailey	Moderate-High	Moderate	Moderate-High	
Buffalo Creek	High	Low	High	
Cheesman	Moderate	Moderate	Moderate	
Craig Creek	High	Low	Moderate-High	
Deer Creek	Very High	High	Very High	
Disappearing Creek	High	Low	Moderate-High	
Elk Creek	Moderate-High	High	High	
Fourmile/Deckers	High	Low	High	
Geneva Creek	Moderate-High	Low	Moderate	
Goose Creek	High	Low	High	
Lost Creek	Low	Low	Moderate	
Lower Trout Creek	Low	Moderate	Moderate	
Lowest North Fork	Moderate	Moderate-High	Moderate-High	
Manitou Park	Low	Moderate-High	Moderate	
North Fork Headwaters	Moderate-High	Low	Moderate-High	
Pine-Rowland	Low	High	Moderate-High	
Rule Creek	Moderate-High	High	High	
South Platte Canyon	Moderate	Low	Moderate	
Upper Trout Creek	Moderate	Very High	Moderate-High	
Waterton/Deckers	Low	Low	Low	
West Creek	Low	Moderate	Moderate	
Wigwam Creek	High	Low	High	

TABLE A-5. UPPER SOUTH PLATTE WATERSHED FLOODING/DEBRIS FLOW RANKING



FIGURE A-5. UPPER SOUTH PLATTE WATERSHED FLOODING/DEBRIS FLOW RANKING MAP

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 as a result of soil heating (Hungerford et al. 1991).

The U.S. Department of Agriculture - Natural Resources Conservation Service (NRCS) STATSGO soils data were used for this analysis because the SSURGO data were not available. The potential for soil loss following a wildfire was determined by using a combination of two standard erodibility indicators. The base predictions of post-fire soil erosion hazard used a combination of the soil's inherent susceptibility to erosion (K factor) and land slope derived from USGS 30m digital elevation models. The K factor data (kwfact or K_w) from the STATSGO spatial database were combined with a slope grid using Natural Resources Conservation Service (USDA NRCS 1997) slope-soil relationships (Table A-6) to create a grid classified into slight, moderate, severe and very severe erosion hazard ratings.

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

TABLE A-6. CRITERIA FOR DETERMINING POTENTIAL SOIL ERODIBILITY

Soil scientists have observed that K factor in the Upper South Platte Watershed does not adequately identify soil erodibility on granitic soils. Therefore, where substantial areas of granitic soils exist, a geology layer was used to identify areas of granitic soils, and the erodibility rating was increased for those soils. The soils erodibility analysis was extracted from the 1999 Upper South Platte Landscape Assessment (Foster Wheeler Environmental), which is presented in Table A-7 and mapped on Figure A-6.

WATERSHED NAME	SOIL ERODIBILITY Score	SOIL ERODIBILITY Hazard Ranking
Bailey	88	Very High
Buffalo Creek	59	High
Cheesman	36	Moderate
Craig Creek	87	Very High
Deer Creek	61	High
Disappearing Creek	63	High
Elk Creek	87	Very High
Fourmile/Deckers	55	Moderate-High
Geneva Creek	71	High
Goose Creek	63	High
Lost Creek	63	High
Lower Trout Creek	38	Moderate
Lowest North Fork	88	Very High
Manitou Park	31	Moderate
North Fork Headwaters	65	High
Pine-Rowland	88	Very High
Rule Creek	31	Moderate
South Platte Canyon	55	Moderate-High
Upper Trout Creek	31	Moderate
Waterton/Deckers	55	Moderate-High
West Creek	22	Low
Wigwam Creek	55	Moderate-High

TABLE A-7. UPPER SOUTH PLATTE WATERSHED SOIL ERODIBILITY RANKING



FIGURE A-6. UPPER SOUTH PLATTE WATERSHED SOIL ERODIBILITY RANKING MAP

COMPONENT 4 - WATER USES RANKING

Water intakes, diversions and storage reservoirs, and streams that are used as conveyances are more susceptible than pipelines to the effects of wildfires. These structures have been identified for the Colorado Source Water Assessment phase completed by the Colorado Department of Public Health and Environment. The water locations of the surface drinking water supply collection points, from the Source Water Assessment and Protection (SWAP) Program, in the Upper South Platte Watershed were used to define the sixth-level watersheds that contain water supply nodes. Risks to water uses were evaluated using the Water Supply Nodes tool. This test case did not use the source water assessment areas (SWAAs) developed by the SWAP Program in the Water Uses Ranking. The SWAAs did not supply additional separation between sixth-level watersheds than that supplied by the water nodes themselves in this watershed. However, the SWAAs are a valuable tool that likely will be useful in other watersheds.

The sixth-level watersheds that contain water supply nodes were identified based on data from the Colorado Department of Public Health and Environment SWAP Program. The water node ranking was based on the presence of one or more nodes within each sixth-level watershed (Table A-8). If a sixth-level watershed contained one or more nodes, it was given a "yes" in Table A-8.

WATERSHED NAME	WATER SUPPLY NODE PRESENCE
Bailey	Yes
Buffalo Creek	Yes
Cheesman	Yes
Craig Creek	No
Deer Creek	No
Disappearing Creek	No
Elk Creek	Yes
Fourmile/Deckers	No
Geneva Creek	No
Goose Creek	No
Lost Creek	No
Lower Trout Creek	No
Lowest North Fork	No
Manitou Park	No
North Fork Headwaters	No
Pine-Rowland	No
Rule Creek	No
South Platte Canyon	Yes
Upper Trout Creek	Yes
Waterton/Deckers	No
West Creek	No
Wigwam Creek	No

TABLE A-8. UPPER SOUTH PLATTE WATERSHED WATER SUPPLY NODE PRESENCE

Front Range Watershed Protection Data Refinement Work Group

Watershed Assessment Technical Approach

OVERALL WATERSHED RANKING

Composite Hazard Ranking

The Composite Hazard Ranking is the combination of the rankings of the first three components (Wildfire Hazard, Flooding/Debris Flow Risk and Soil Conditions). They were combined by averaging the numerical ranking values of the Wildfire Hazard, Flooding or Debris Flow Risk and Soil Erodibility for each sixth-level watershed into a Composite Hazard Ranking (Table A-9) and was mapped (Figure A-7).

		FLOODING OR	SOIL	
	WILDFIRE	DEBRIS FLOW	ERODIBILITY	COMPOSITE
WATERSHED NAME	RANKING	RANKING	RANKING	RANKING
Bailey	Moderate-High	Moderate-High	Very High	High
Buffalo Creek	High	High	High	High
Cheesman	Very High	Moderate	Moderate	Moderate-High
Craig Creek	Moderate	Moderate-High	Very High	High
Deer Creek	Moderate	Very High	High	High
Disappearing Creek	Moderate	Moderate-High	High	Moderate-High
Elk Creek	High	High	Very High	Very High
Fourmile/Deckers	Very High	High	Moderate-High	Very High
Geneva Creek	Low	Moderate	High	Moderate
Goose Creek	High	High	High	High
Lost Creek	Low	Moderate	High	Low
Lower Trout Creek	Very High	Moderate	Moderate	Moderate-High
Lowest North Fork	Very High	Moderate-High	Very High	Very High
Manitou Park	High	Moderate	Moderate	Moderate
North Fork Headwaters	Low	Moderate-High	High	Moderate
Pine-Rowland	Very High	Moderate-High	Very High	Very High
Rule Creek	Moderate-High	High	Moderate	Moderate
South Platte Canyon	Very High	Moderate	Moderate-High	High
Upper Trout Creek	Moderate-High	Moderate-High	Moderate	Moderate-High
Waterton/Deckers	Very High	Low	Moderate-High	Moderate-High
West Creek	Very High	Moderate	Low	Moderate
Wigwam Creek	High	High	Moderate-High	High

TABLE A-9. UPPER SOUTH PLATTE WATERSHED COMPOSITE HAZARD RANKING



FIGURE A-7. UPPER SOUTH PLATTE WATERSHED COMPOSITE HAZARD MAP

Final Watershed Prioritization

The Final Watershed Prioritization involves combining the Composite Hazard Ranking map and the Water Uses Ranking from above. The Water Uses Ranking resulted in a numeric ranking of either zero or one. Combining the Composite Hazard Ranking and Water Uses Ranking involved increasing the hazard categories for each sixth-level watershed from the Composite Hazard Ranking map by one category for each watershed with a Water Uses Ranking value of one. The result was mapped as the Final Watershed Prioritization map (Figure A-8).



FIGURE A-8. UPPER SOUTH PLATTE FINAL WATERSHED PRIORITIZATION MAP

Front Range Watershed Protection Data Refinement Work Group

Watershed Assessment Technical Approach

Zones of Concern

The Work Group identified an important risk factor for water uses related to transport of debris and sediment from upstream sources. The area upstream of important water supply reservoirs or diversions that have a higher potential for contributing significant sediment or debris is called the Zone of Concern. These Zones of Concern can be used to define project areas for stakeholders on which to focus watershed protection actions. The sixth-level watersheds within that distance are considered to be within the Zone of Concern.

The Upper South Platte Watershed Assessment used the Zones of Concern based on an 11-mile stream distance upstream based on experience following the Buffalo Creek Fire in 1996 (Moody and Martin 2001). Sediment and debris from the burned area were transported this distance along the stream course downstream to a critical water supply reservoir, Strontia Springs Reservoir. Ten Zones of Concern were identified (Table A-10), the boundaries were determined by GIS analysis (Figure A-9) and were overlaid on the Final Watershed Prioritization map (Figure A-10).

ZONES OF CONCERN
Bailey
Elk Creek
Cheesman
High Line Canal
Moore Dale Ranch
Santa Maria
Shawnee
Strontia
Windy Peaks
Woodland Park

TABLE A-10. UPPER SOUTH PLATTE WATERSHED ZONES OF CONCERN



FIGURE A-9. UPPER SOUTH PLATTE WATERSHED ZONES OF CONCERN



FIGURE A-10. UPPER SOUTH PLATTE ZONES OF CONCERN WITH FINAL WATERSHED PRI-ORITIZATION MAP

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