APPENDIX F - ROCK TPA ASSESSMENT OF UPLAND SEDIMENT SOURCES FOR TMDL DEVELOPMENT

Appendix F is based report prepared for the DEQ by ATKINS, August 2012.

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F1.0 INTRODUCTION

An assessment of the sediment loading from hillslope erosion within the Rock TMDL Planning Area (TPA) was performed to facilitate the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. Upland sediment loading from hillslope erosion was modeled using a Universal Soil Loss Equation (USLE) based model, which was combined with a sediment delivery ratio (SDR) and riparian health assessment to predict the amount of sediment delivered to streams in the Rock TPA. The USLE based model was implemented as a watershed-scale, raster-based, GIS model using ArcGIS software.

F1.1 SEDIMENT IMPAIRMENTS

The Rock TPA encompasses an area of approximately 890 square miles in Granite and Missoula counties in western Montana. The Rock TPA is contained within the Flint-Rock Creeks HUC8 (17010202). Within the Rock TPA, there are nine waterbody segments listed on the 2012 303(d) List for sediment-related impairments, including Eureka Gulch, Brewster Creek, South Fork Antelope Creek, Quartz Gulch, East Fork Rock Creek, Miners Gulch, Flat Gulch, Sluice Gulch, and Scotchman Gulch (**Table F1-1**). The Antelope Creek watershed, Upper Willow Creek watershed, and West Fork Rock Creek watershed were also included in this assessment to provide supporting information, though these streams do not appear on the 2012 303(d) List as impaired for sediment.

Table F1-1. Waterbody Segments Addressed during the USLE Assessment

TPA	Segment ID	Waterbody Description
Rock	MT76E002_090	EUREKA GULCH, confluence of Quartz Gulch and Basin Gulch to mouth (Rock Creek)
Rock	MT76E002_050	BREWSTER CREEK, East Fork to mouth (Rock Creek)
Rock	MT76E002_060	SOUTH FORK ANTELOPE CREEK, headwaters to mouth (Antelope Creek), T6N R15W S22
Rock	MT76E002_070	QUARTZ GULCH, headwaters to mouth (Eureka Gulch)
Rock	MT76E002_020	EAST FORK ROCK CREEK, East Fork Reservoir to mouth (Middle Fork Rock Creek)
Rock	MT76E002_160	MINERS GULCH, headwaters to mouth (Upper Willow Creek), T8N R15W S23
Rock	MT76E002_120	FLAT GULCH, headwaters to mouth (Rock Creek)
Rock	MT76E002_110	SLUICE GULCH, headwaters to mouth (Rock Creek)
Rock	MT76E002_100	SCOTCHMAN GULCH, headwaters to mouth (Upper Willow Creek)
Rock	MT76E002_061	ANTELOPE CREEK, headwaters to mouth (Rock Creek)
Rock	MT76E002_040	UPPER WILLOW CREEK, headwaters to the mouth (Rock Creek)
Rock	MT76E002_030	WEST FORK ROCK CREEK, headwaters to mouth (Rock Creek)

F2.0 METHODS

Upland sediment loading from hillslope erosion was modeled using a Universal Soil Loss Equation (USLE) based model, which was combined with a sediment delivery ratio (SDR) and riparian health assessment to predict the amount of sediment delivered to streams in the Rock TPA. Methods used in this assessment are described in *Quality Assurance Project Plan: Assessment of Upland Sediment Sources for TMDL Development (Task Order 18: Task 2c)* (U.S. Environmental Protection Agency, 2011) and summarized in the following sections.

F2.1 SUBWATERSHED DELINEATION

Prior to USLE model development, subwatersheds were delineated in which the Rock TPA upland sediment assessment would be conducted. Subwatersheds were delineated on the basis of the U.S. Geological Survey (USGS) 6th Hydrologic Unit Code (HUC12) layer and modified where necessary to delineate the subwatersheds of interest (**Table F2-1** and **Figure F2-1**). The following subwatersheds were smaller than the USGS HUC12 subwatersheds and were created using watershed delineation tools in ArcGIS and a 30-meter DEM: Basin Gulch, Eureka Gulch, Flat Gulch, Quartz Gulch, Sluice Gulch, South Fork Antelope Creek, Miners Gulch, and Scotchman Gulch. These are identified with a subwatershed ID of "sub6code" in **Table F2-1** and **Figure F2-1**. The delineated portion of the Eureka Gulch subwatershed extends along the listed segment of Eureka Gulch downstream of the confluence with Basin Gulch and Quartz Gulch. In addition, two HUC12 subwatersheds encompass smaller delineated subwatersheds: the Middle Upper Willow Creek HUC12, which contains the Miners Gulch and Scotchman Gulch subwatersheds, and the Antelope Creek HUC12, which contains the South Fork Antelope Creek subwatershed. The remaining portions of the HUC12 outside of which the "sub6code" subwatersheds occur are identified as "remainder".

Table F2-1. Subwatersheds in the Rock TPA

HUC10 Name	HUC12 Name	Subwatershed ID
East Fork Rock Creek	East Fork Reservoir	East Fork Reservoir
	East Fork Rock Creek	East Fork Rock Creek
	Meadow Creek	Meadow Creek
Lower Rock Creek	Brewster Creek	Brewster Creek
Upper Rock Creek	Rock Creek-Flat Gulch	Basin Gulch_sub6code
		Eureka Gulch_sub6code(segment)
		Flat Gulch_sub6code
		Quartz Gulch_sub6code
	Rock Creek-Mallard Creek	RockMallard_remainder(Antelope)
		South Fork Antelope Creek_sub6code
	Rock Creek-Sluice Gulch	Sluice Gulch_sub6code
Upper Willow Creek	Lower Upper Willow Creek	Lower Upper Willow Creek
	Middle Upper Willow Creek	Middle Upper Willow Creek_remainder
		Miners Gulch_sub6code
		Scotchman Gulch_sub6code
	Upper Upper Willow Creek	Upper Upper Willow Creek
	Upper Willow Creek Headwaters	Upper Willow Creek Headwaters
West Fork Ross Creek*	Lower West Fork Ross Creek*	Lower West Fork Rock Creek
	Middle West Fork Ross Creek*	Middle West Fork Rock Creek
	Upper West Fork Ross Creek*	Upper West Fork Rock Creek
	West Fork Ross Creek Headwaters*	West Fork Rock Creek Headwaters

*USGS HUC10 and HUC12 mis-identify the West Fork Rock Creek watershed as the West Fork Ross Creek

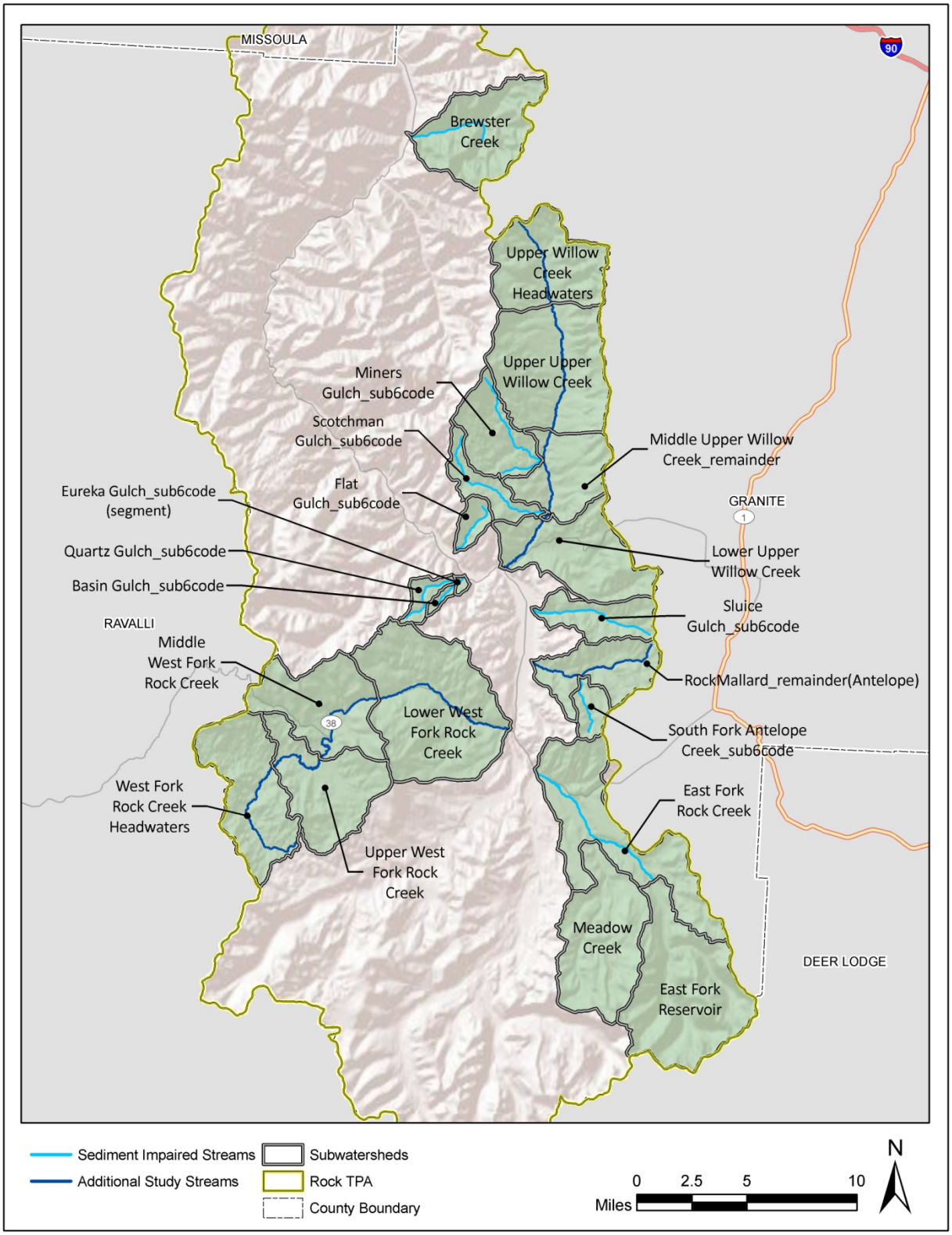

Figure F2-1. Subwatersheds in the Rock TPA

F2.2 ULSE MODEL INPUT PARAMETERS

The USLE model requires five landscape factors that are combined to predict upland soil loss, including a rainfall factor (R), soil erodibility factor (K), length and slope factors (LS), cropping factor (C), and management practices factor (P). The general form of the USLE equation has been widely used for upland sediment erosion modeling and is presented as (Brooks et al., 1997):

$$A = RK(LS)CP \text{ (in tons per acre per year)}$$

For this assessment, the USLE based model was parameterized using a number of published data sources, including information from: (1) U.S. Geological Survey (USGS), (2) Spatial Climate Analysis Service (SCAS), and (3) Natural Resource Conservation Service (NRCS). Additionally, local information regarding specific land cover was acquired from the U.S. Forest Service (USFS) and the NRCS. Specific GIS data layers used in the modeling effort are presented in the following sections.

F2.2.1 R-Factor

The **R-factor** characterizes the effect of raindrop impact and runoff rates associated with a rainstorm, which is reported in 100s of ft-tons rainfall/ac-yr. The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service of Oregon State University at a 4 km grid cell resolution based on Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation data. The R-factor is determined using the kinetic energy of a rainfall event and the maximum 30-minute rainfall intensity for an area. For the purposes of this analysis, the SCAS R-factor grid was projected to Montana State Plane Coordinates and interpolated to a 10m grid cell (**Figure F2-2**).

F2.2.2 K-Factor

The **K-factor** is a soil erodibility factor that quantifies the susceptibility of soil to erosion. It is a measure of the average soil loss from a particular soil in continuous fallow derived from experimental data (tons soil/100 ft tons rainfall). Polygon data of K-factor values in the Rock TPA was obtained from the NRCS General Soil Map (STATSGO) database and the NRCS Soil Survey Geographic (SSURGO) database. The SSURGO database was used where available, which included all of the subwatersheds in the Rock TPA except Brewster Creek. While the SSURGO database has higher resolution and is more current than the STATSGO database, the SSURGO database for the Rock TPA did not contain the required K-factor for the entire study area. When the SSURGO database lacked K-factor values, the K-factor was derived from the STATSGO database in which the USLE K-factor is a standard component. Soils polygon data was summarized and interpolated to a 10m grid cell (**Figure F2-2**).

F2.2.3 LS-Factor

The **LS-factor** is a function of the slope and flow length of the eroding slope or cell (units are dimensionless). The LS-factor was derived from 10m USGS digital elevation model (DEM) grid data and interpolated to a 10m grid cell. For the purpose of computing the LS-factor, slope is defined as the average land surface gradient per cell, while the flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. The equation used for calculating the slope length and slope factor is given in the updated definition of RUSLE, as published in USDA handbook #703 (Renard et al., 1997).

L, the slope length factor in the RUSLE equation, serves to reference the erosion estimate for a horizontally projected slope length to the experimentally measured erosion for a 72.6 foot (22.1 meters) plot.

$L = (\lambda/72.6)^m$

where:

λ = the horizontal projection of slope length

72.6 = the RUSLE unit plot length in feet

m = the variable slope length component, related to the ratio (β) of rill erosion (caused by flow) to interrill erosion (caused by raindrop impact) defined in the following equation:

$= \beta/(1 + \beta)$

And $\beta = (\sin \Theta/0.0896) / [3.0(\sin \Theta)^{0.8} + 0.56]$

Soil loss increases more rapidly with slope steepness than it does with slope length. This is quantified by S, the slope steepness factor of the RUSLE.

$S = 10.8 \sin \theta + 0.03$ for $\theta < 9\%$

$= 16.8 \sin \theta - 0.50$ for $\theta \geq 9\%$

where:

θ = the slope angle

Combined, these factors can be written:

$$LS = S_i (\lambda_i^{m+1} - \lambda_{i-1}^{m+1}) / (\lambda_I - \lambda_{i-1}) (72.6)^m$$

where:

λ_i = length in feet from top of slope to lower end of the segment. This value was determined by applying GIS based surface analysis procedures to the each DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters.

S_i = slope steepness factor for the segment

$= 10.8 \sin \theta + 0.03$ for $\theta < 9\%$

$= 16.8 \sin \theta - 0.50$ for $\theta \geq 9\%$

The LS-Factor was calculated using a C++ program which automatically processes the DEM input (U.S. Environmental Protection Agency, 2011; Van Remortel et al., 2004). The program evaluates each individual grid cell based on the LS factors mentioned above. The C++ program begins with a fill function of any depressions or sinks found on the DEM input. The highest elevation points on the DEM are then identified by the program and the flow direction is determined. In situations of converging flow, the flow direction of steepest decent takes precedence. The distance between the centers of one grid cell to the next grid cell is then calculated by the C++ program as the non-cumulative slope length (NCSL). A cumulative slope length is then computed by summing the NCSL from each grid cell, beginning at a high point and moving down along the direction of steepest descent. The calculated slope angle of each cell is first examined by the C++ program, and a sub-routine calls for a table lookup function. The range in which the slope angle falls within the table is indentified and a corresponding slope length exponent (m)

is assigned. The program has a function called the cutoff slope angle and is defined as the ratio of change in slope angle from one grid cell to the next along the flow direction. When the slope angle decreases sufficiently, the cumulative slope length calculation stops and then resumes when the land surface extends further downhill in order to recognize areas of deposition versus erosion. The final grid produced combines all the factors into the final LS factor in the formula given above (**Figure F2-2**).

F2.2.3.1 Digital Elevation Model

The digital elevation model (DEM) is the base layer used for developing the LS factor for the USLE analysis. The USGS 10m (1/3 Arc-second) DEM was used for this analysis. The 10m DEM was projected into Montana State Plan Coordinates and interpolated to a 10m grid cell to render the delineated stream network more representative of the actual size of Rock TPA streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m DEM was subjected to standard hydrologic preprocessing, including filling of sinks to create a positive drainage condition for all areas of the watershed (**Figure F2-2**).

F2.2.3.2 Stream Network Delineation

The stream network for each subwatershed in the Rock TPA was derived from the 10m DEM using TauDEM (Terrain Analysis Using Digital Elevation Models) software developed by the Utah State University Hydrology Research Group (http://hydrology.usu.edu/taudem/taudem5.0/index.html). The stream network was generated using TauDEM with the threshold adjusted to most closely mirror the 1:24,000 NHD stream layer.

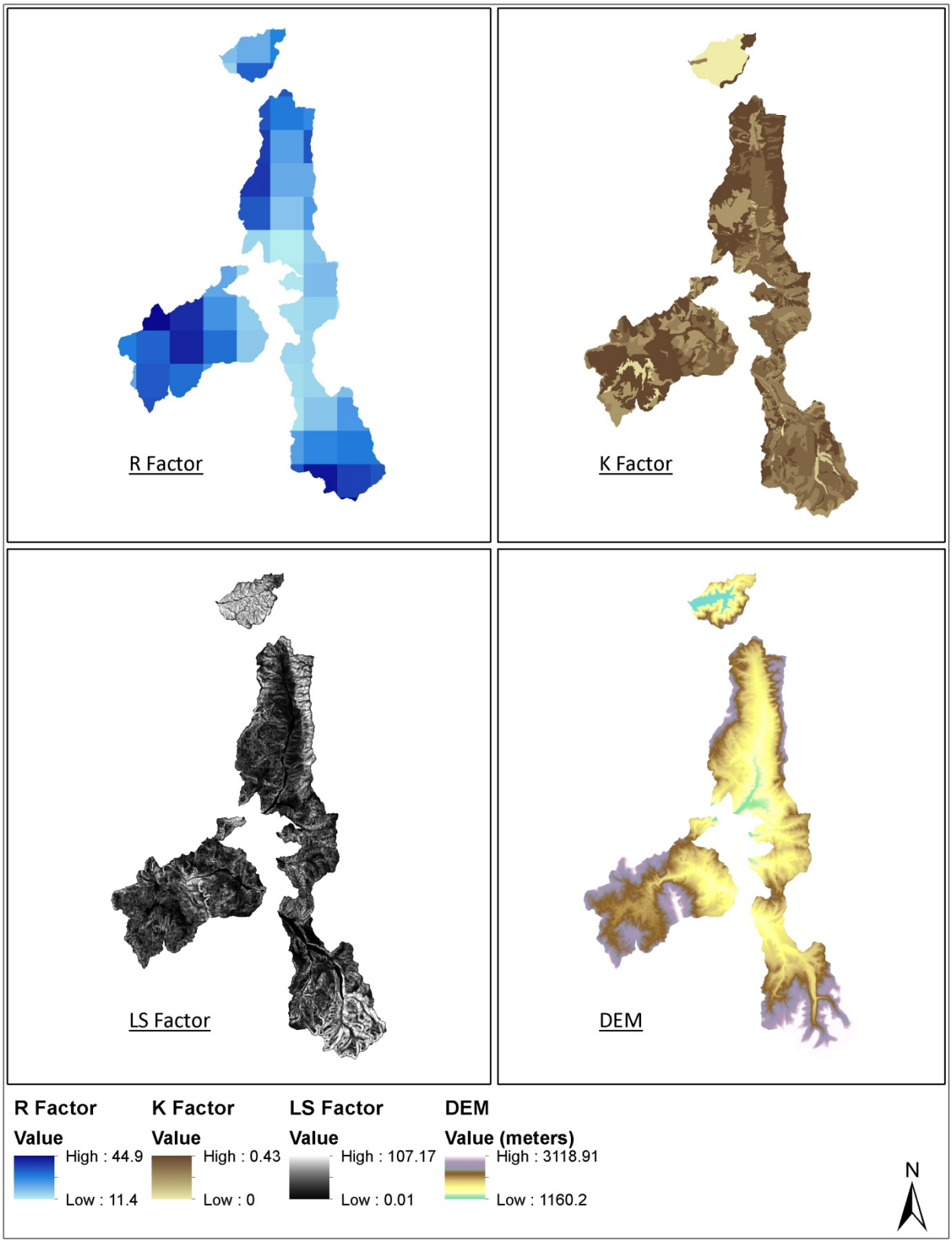

Figure F2-2. R-Factor, K-Factor, LS-Factor, and DEM for the Rock TPA

F2.2.4 C-Factor

The **C-factor** is a crop management value that represents the ratio of soil erosion from a specific cover type compared to the erosion that would occur on a clean-tilled fallow under identical slope and rainfall. The C-factor integrates a number of variables that influence erosion including vegetative cover, plant litter, soil surface, and land management. Original ULSE C-factors were experimentally determined for agricultural crops and have since been modified to include rangeland and forested land cover types. For this assessment, the C-factor was estimated for various land cover types using the National Land Cover Database and C-factor interpretations applied during previous USLE modeling projects conducted for sediment TMDL development. C-factors are intended to be conservatively representative of conditions within the Rock TPA.

F2.2.4.1 National Land Cover Database

The 2006 National Land Cover Database (NLCD) was obtained from the Multi-Resolution Land Characteristics (MRLC) Consortium and used for establishing USLE C-factors in the Rock TPA. The 2006 NLCD is a categorized 30 meter Landsat Thematic Mapper image shot in 2006. The NLCD image was projected to Montana State Plane Coordinates and interpolated to a 10m grid cell (**Figure F2-3**). For this analysis, areas described as 'cultivated crops' in the NLCD database were redefined as 'hay/pasture' to better represent agricultural practices in the Rock TPA based on input from the local Natural Resources Conservation Service representative. NLCD land cover types for the Rock TPA are described in **Attachment F1**.

F2.2.4.2 C-Factor Derivation

USLE C-factors for existing conditions were assigned to the NLCD land cover types in the Rock TPA based on ground cover percentages in *Table 10 – Factor C for permanent pasture, range, and idle land* as presented in Predicting Rainfall Erosion Losses: A Guide to Conservation Planning (Wischmeier and Smith, 1978) and summarized in **Table F2-2** and **Attachment F2**. In order to estimate the potential sediment reduction that might be achieved under a Best Management Practices (BMP) scenario, the USLE-based model was also run using C-factors representing desired conditions. Land cover types identified as 'shrub/scrub', 'grasslands/ herbaceous', and 'hay/pasture' were conservatively adjusted to reflect a 10% improvement in ground cover over existing conditions as depicted in **Table F2-3**.

Table F2-2. C-factors for Existing and Desired Conditions

NLCD Code	Description	C-Factor Existing Conditions	C-Factor Desired Conditions
0*	Transitional*	0.006	0.006
11	Open Water	-	-
21	Developed, Open Space	0.003	0.003
22	Developed, Low Intensity	0.001	0.001
31	Barren Land	0.001	0.001
42	Evergreen Forest	0.003	0.003
52	Shrub/Scrub	0.046	0.031
71	Grassland/Herbaceous	0.042	0.035
81	Hay/Pasture	0.020	0.013
90	Woody Wetlands	0.003	0.003

* A code of "0" and a description of "Transitional" was developed to describe areas of Fire or Timber Harvest

Table F2-3. Percent Ground Cover for Existing and Desired Land Cover Types

Land Cover	Existing % ground cover	Desired % ground cover
Shrub/Scrub	55	65
Grassland/Herbaceous	55	65
Hay/Pasture	75	85

It is acknowledged that land cover is variable within and across watersheds and changes seasonally. The C-factors used for the USLE-based model are intended to represent typical annual conditions at a coarse scale and the percent of improvement achievable via the implementation of BMPs.

F2.2.4.3 Fire and Timber Harvest Adjustments

The 2006 NLCD layer was adjusted to quantify the amount of fire and timber harvest that have occurred since 2006 and also to identify previously disturbed areas that have become reforested over that same period. Areas with fire or timber harvest since 2006 were coded '0', defined as 'transitional', and assigned a C-factor of 0.006 (**Table F2-2** and **Figure F2-3**). Adjustments on U.S. Forest Service lands were performed based on fire and timber harvest record polygons provided by the U.S. Forest Service, while a digitized polygon layer of adjustments for fire and timber harvest on non-USFS property was created by comparing the 2006 NLCD layer with the 2011 NAIP aerial imagery. Adjustments for reforestation were also examined by comparing the 2006 NLCD layer with the 2011 NAIP aerial imagery, though no areas of reforestation were observed.

In the Rock TPA, recent timber harvest was observed on both private and public lands in the Upper Willow Creek watershed and the West Fork Rock Creek watershed, with the only large fires since 2006 occurring in the Upper Willow Creek watershed (**Figure F2-4**). Timber harvest mapped from the 2011 NAIP imagery in the Upper Willow Creek watershed has occurred primarily on U.S. Bureau of Land Management and Montana Department of Natural Resources and Conservation lands, while in the West Fork Rock Creek watershed recent timber harvest has occurred on private lands. Recent timber harvest is limited on USFS land and generally occurs adjacent to the other timber harvests.

F2.2.5 P-Factor

The **P-factor,** or conservation practice factor, is a function of the interaction of the supporting land management practice and slope. It incorporates the use of erosion control practices such as strip-cropping, terracing and contouring, and is applicable only to agricultural lands. Values of the P-factor compare straight-row farming practices with that of certain agriculturally based conservation practices. The P-factor was set to one for this analysis based on existing practices within the Rock TPA.

F2.3 DISTANCE AND RIPARIAN HEALTH ASSESSMENT BASED SEDIMENT DELIVERY RATIO

Results from the USLE hillslope erosion assessment were combined with a sediment delivery ratio (SDR) and riparian health assessment to predict the amount of sediment delivered to streams in the Rock TPA. Soil lost from one area on a hillslope due to erosive processes is typically re-deposited a short distance downslope and therefore not all of the sediment produced from a hillslope erosion event is delivered to a stream channel. As TMDLs deal specifically with sediment delivered to the stream, a method for accounting for sediment re-deposition and ultimate delivery to streams was developed. In the Rock TPA, sediment re-deposition is accounted for through the application of a sediment delivery ratio (SDR) which

estimates the percentage of hillslope sediment produced that is ultimately delivered to the stream. This distance based sediment delivery ratio reflects the relationship between downslope travel distance and ultimate sediment delivery. In addition to sediment re-deposition during hillslope transport processes, riparian zones also reduce sediment inputs to stream channels. The width and quality of the riparian vegetation buffer zone determines its effectiveness as a sediment filter. Thus, a riparian health assessment was included along with the distance based sediment delivery analysis.

F2.3.1 Riparian Health Assessment

A riparian health assessment was conducted during the aerial assessment reach stratification process in which reaches were delineated based on a combination of physical attributes (ecoregion, valley slope, valley confinement, and stream order) and the presence and degree of adjacent human activity. For each reach, a riparian health assessment was performed using aerial photos, field notes, and best professional judgment. Riparian health for each reach was designated as 'poor', 'poor/fair', 'fair', 'fair/good', or 'good' based on adjacent land use practices, streamside vegetation, and the presence or absence of human activities (**Figure F2-5**). The cumulative length of the reaches within each riparian health category was tallied for each stream segment and the percent of stream length in each riparian health category was calculated. This information was then used to refine estimates of sediment delivery to streams from upland sources by incorporating the results of the riparian health assessment into the distance based sediment delivery ratio calculation.

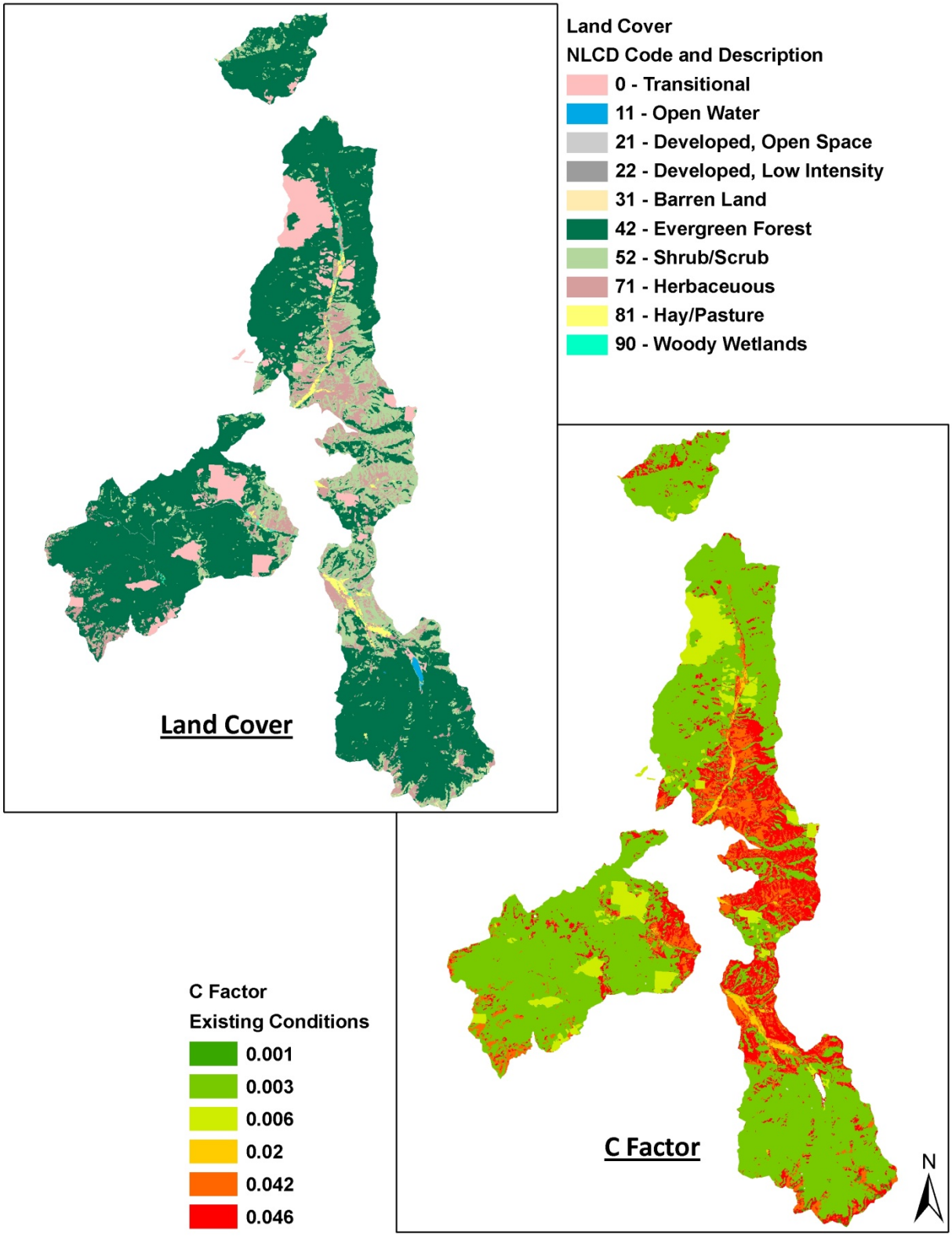

Figure F2-3. Land Cover and C-Factors for the Rock TPA

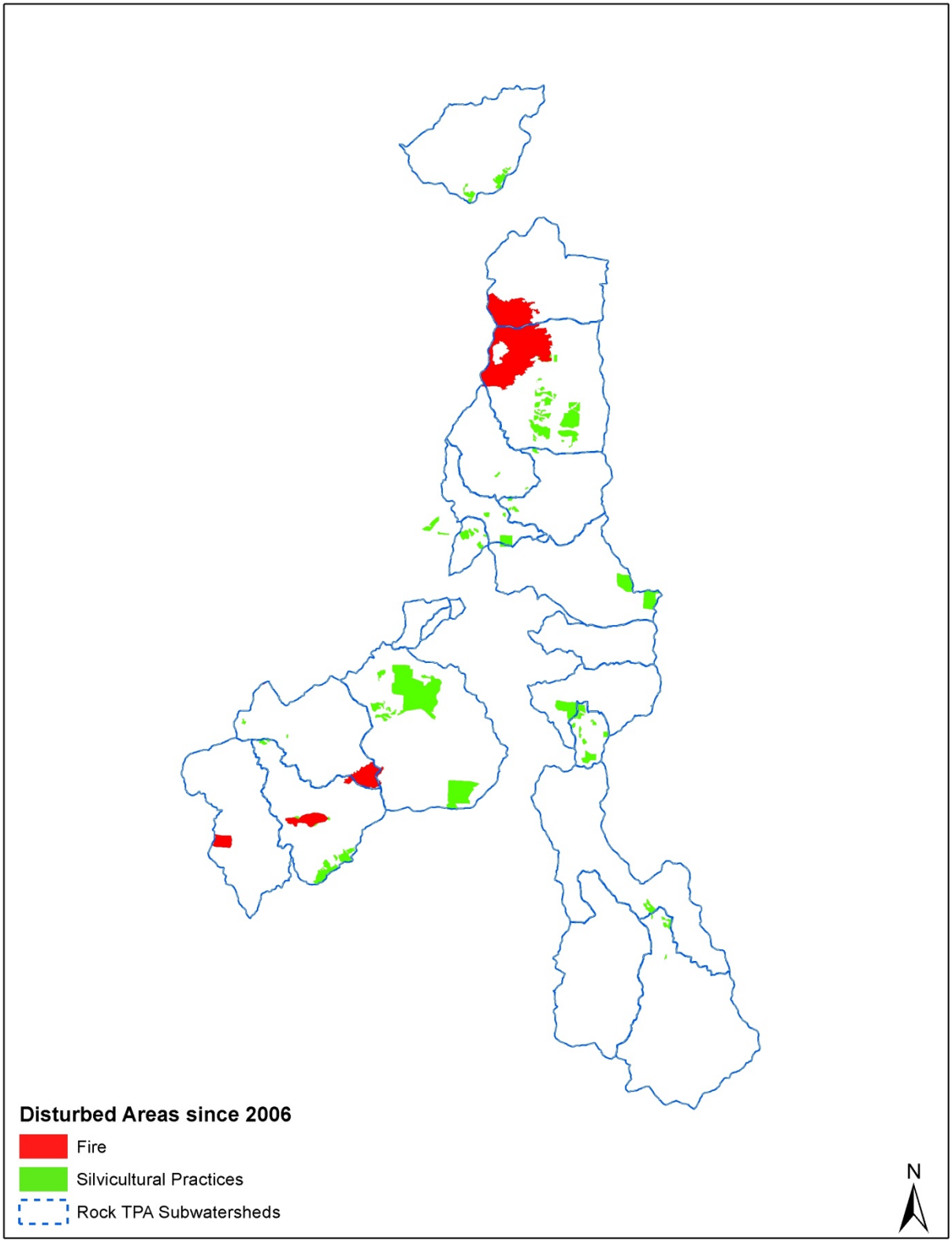

Figure F2-4. Fire and Timber Harvest Areas in the Rock TPA since 2006

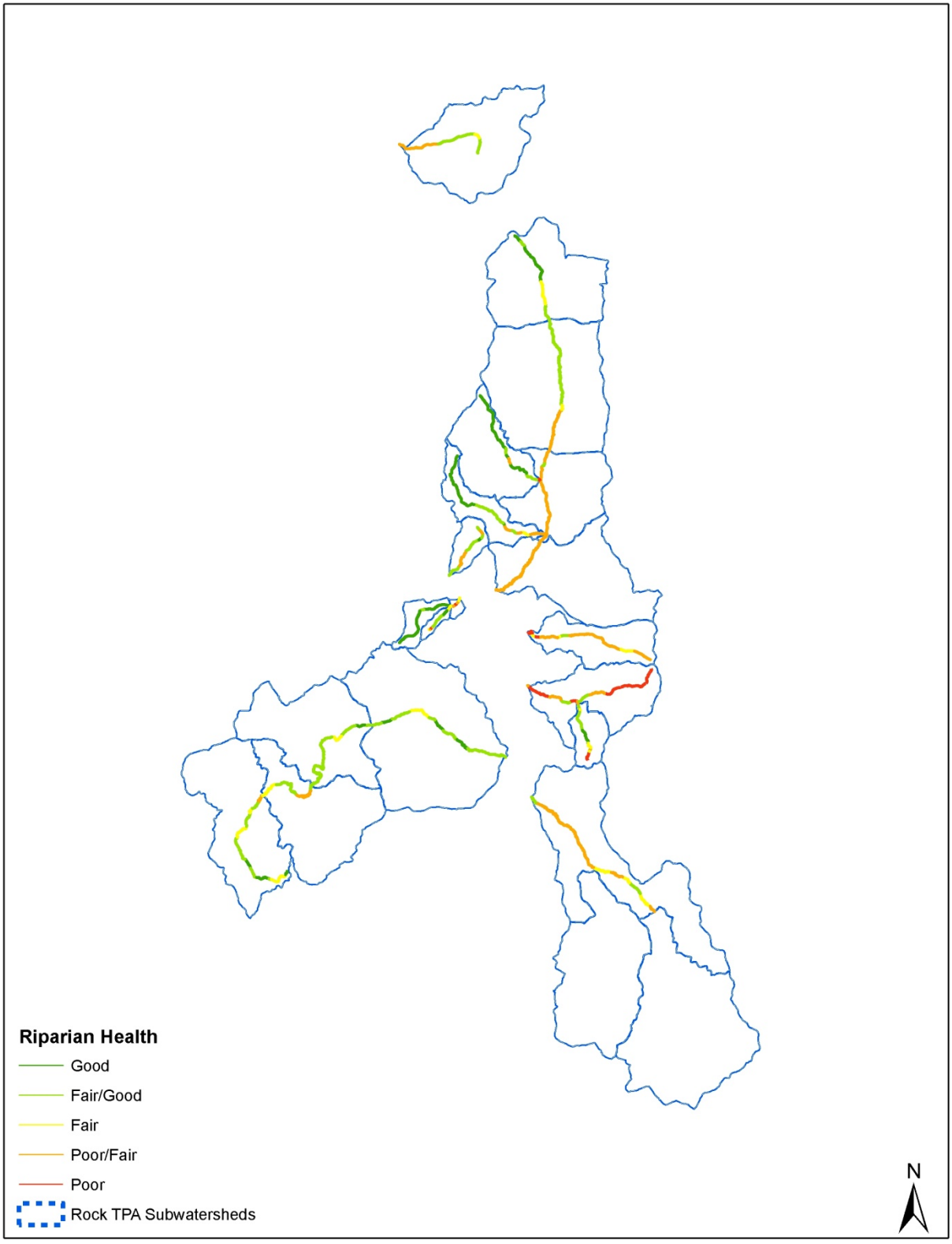

Figure F2-5. Aerial Assessment Reach Stratification Riparian Health Assessment

F2.3.2 Distance based Sediment Delivery Ratio

The distance based sediment delivery ratio was calculated in the model for each grid cell based on the observed relationship between the distance from the delivery point to the stream and the percent of eroded sediment delivered to the stream using an equation developed by Megehan and Ketcheson (1996). Megahan and Ketcheson (1996) found that the relationship between the percentage (by volume) of sediment that travels a given percentage of the maximum distance is as shown in **Figure F2-6**. Megahan and Ketcheson's logarithmic regression of the data permits this relationship to be expressed by the equation presented in **Figure F2-6**, which may be restated as a function of three variables:

Volume % = or 103.62*EXP(-((D/Dtotal)*100)/32.88))-5.55

where:

Volume% = the percentage of sediment mobilized from a source that travels at least distance D from that source

D = distance from the sediment source, and

Dtotal = the maximum distance that sediment travels from the source.

As the Megehan and Ketcheson equation is dimensionless, to serve as an SDR it was scaled to the field conditions of the Rock TPA by evaluating the equation with site -specific values for D and Volume% at a single point and then solving for Dtotal. Having established a site specific Dtotal, the Megahan and Kecheson equation reduces to the two variables that define a distance based SDR: distance and percent sediment delivered beyond that distance. This SDR was then used to estimate sediment delivery at all points on the sediment delivery path extending from the streambank to a distance Dtotal.

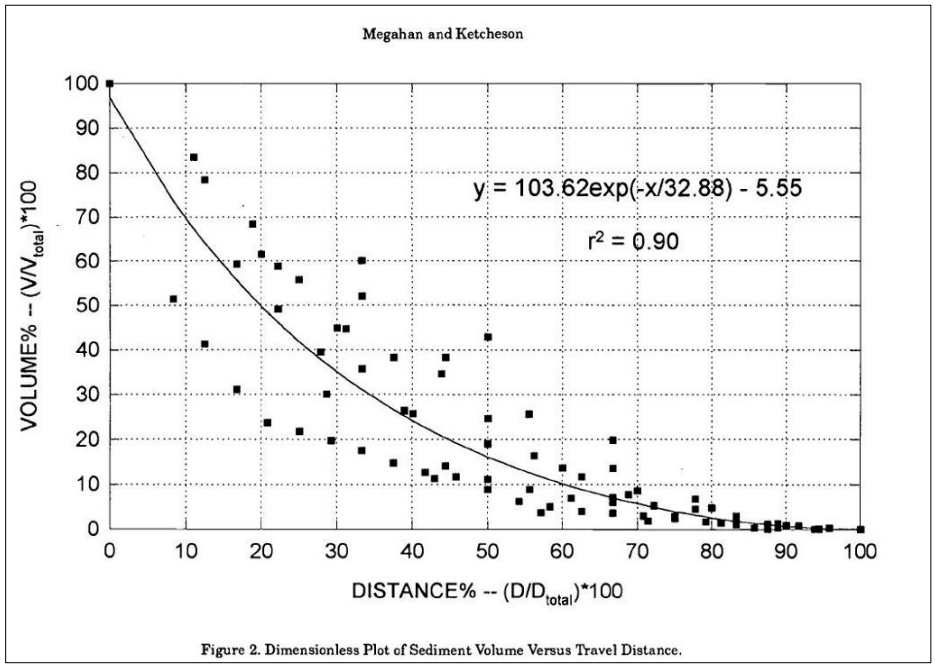

Figure F2-6 Sediment Volume vs. Travel Distance (Megahan and Ketcheson, 1996)

F2.3.3 Subwatershed Specific Sediment Delivery Ratio Scale Factors

Riparian zone sediment filtering capacity is typically expressed as a given percent reduction in delivery of sediment entering a riparian zone of a given buffer width. This rating of a known percent delivery (Volume%) from a known distance from the stream (D) permits scaling of the Megahan and Ketcheson's dimensionless equation (**Section F2.3.2**) for use in predicting percent delivery from other distances. Literature review (Knutson and Naef, 1997; Wegner, 1999) indicates that a 100 foot wide, well vegetated riparian buffer zone can be expected to filter 75-90% of incoming sediment from reaching its stream channel. Accordingly, this analysis conservatively assumes that a sediment reduction efficiency (SRE) of 75% represents the performance of a 100 foot wide, high quality ('good') vegetated riparian buffer. Conversely, this analysis conservatively assumes that a 100 foot wide riparian zone without vegetation cover ('none') would only filter 10% of incoming sediment from reaching its stream. An approximately equal apportionment of the remaining range in sediment reduction efficiency between the 'poor', 'moderately fair' (i.e. 'poor/fair'), 'fair', and 'moderately good' (i.e. 'fair/good') riparian assessment categories results in the riparian buffer sediment reduction efficiencies depicted in **Figure F2-7**.

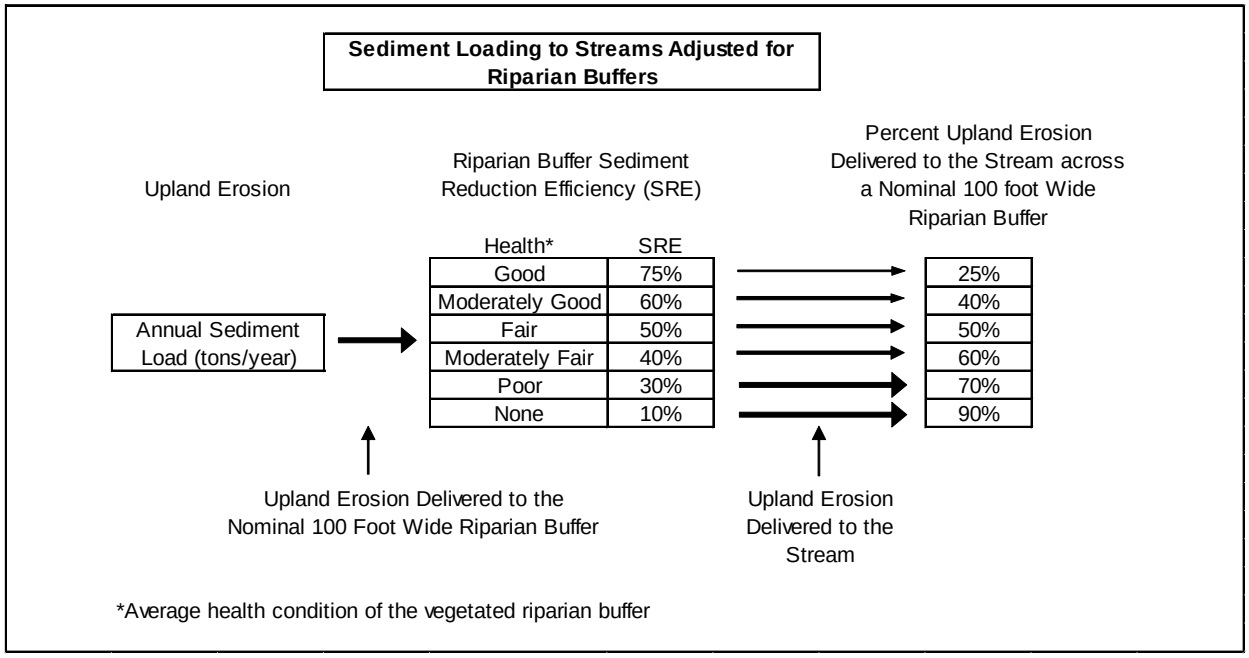

Figure F2-7. USLE Upland Sediment Load Delivery Adjusted for Riparian Buffer Capacity

The Rock TPA riparian health assessment was used to develop a riparian health score based on the sediment reduction percentage for each individual stream segment subwatershed. This value represents the percent reduction in sediment delivery from a nominal 100 foot wide riparian buffer under existing conditions. For the BMP scenario, it was assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer will increase riparian health. The potential to improve riparian health was evaluated for each reach based on best professional judgment through a review of color aerial imagery from 2009 and on-the-ground reconnaissance.

F2.4 MODEL SCENARIOS

Management scenarios include: (1) an existing conditions scenario that considers the current land cover, management practices, and riparian health in the watershed; (2) an upland BMP conditions scenario that considers improved grazing and cover management; (3) a riparian health BMP conditions scenario that considers improved riparian buffer zones; and (4) a riparian health BMP and upland BMP conditions scenario that considers improved riparian buffer zones and grazing and cover management. For each scenario, erosion was differentiated into two source categories: (1) natural erosion that occurs on the time scale of geologic processes and (2) anthropogenic erosion that is accelerated by human-caused activity. For scenarios 2 and 4, land cover types identified as 'shrub/scrub', 'grasslands/ herbaceous', and 'hay/pasture' were conservatively adjusted to reflect a 10% improvement in ground cover over existing conditions as discussed in Section 2.2.4.2 and depicted in **Table F2-3**. For scenarios 3 and 4, the riparian health score was adjusted to reflect improvements in riparian health as discussed in **Section 2.3.3.**

F3.0 RESULTS

Several hillslope erosion modeling scenarios were assessed in the Rock TPA, including an assessment of existing conditions (Scenario 1) and several Best Management Practices (BMP) scenarios examining upland and riparian BMPs (Scenarios 2 through 4) as follows:

Scenario 1 - Existing conditions scenario that considers the current land cover, management practices, and riparian health in the watershed;

Scenario 2 - Upland BMP conditions scenario that considers improved grazing and cover management;

Scenario 3 - Riparian health BMP conditions scenario that considers improved riparian buffer zones;

Scenario 4 - Riparian health BMP and upland BMP conditions scenario that considers improved riparian buffer zones and grazing and cover management.

The results of this assessment are summarized in **Table F3-1**, with the complete modeling results presented for each subwatershed in **Table F3-2**.

Table F3-1. Summary of Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
		Upland Erosion Sediment Load for **Existing Conditions** and **Existing Riparian** Health (tons/year)	Upland Erosion Sediment Load for **BMP Conditions** and **Existing Riparian** Health (tons/year)	**Percent Change from Existing**	Upland Erosion Sediment Load for **Existing Conditions** and **BMP Riparian** Health (tons/year)	**Percent Change from Existing**	Upland Erosion Sediment Load for **BMP Conditions** and **BMP Riparian** Health (tons/year)	**Percent Change from Existing**
West Fork Rock Creek Headwaters	12,944	197.5	168.7	-15%	176.4	-11%	150.9	-24%
Upper West Fork Rock Creek	11,851	72.2	70.3	-3%	65.0	-10%	63.2	-12%
Middle West Fork Rock Creek	12,084	250.5	208.4	-17%	224.1	-11%	187.3	-25%
Lower West Fork Rock Creek	22,486	392.5	316.1	-19%	355.3	-9%	287.4	-27%
West Fork Rock Creek Total	**59,366**	**912.8**	**763.4**	**-16%**	**820.8**	**-10%**	**688.9**	**-25%**
East Fork Reservoir	19,443	555.0	475.2	-14%	242.3	-56%	213.3	-62%
Meadow	14,843	317.9	267.6	-16%	135.4	-57%	116.6	-63%
East Fork Rock Creek	16,367	862.9	621.1	-28%	399.1	-54%	286.8	-67%
East Fork Rock Creek Total	**50,653**	**1735.8**	**1363.9**	**-21%**	**776.8**	**-55%**	**616.7**	**-64%**
Upper Willow Creek Headwaters	11,553	271.2	236.9	-13%	178.6	-34%	156.1	-42%
Upper Upper Willow Creek	17,608	295.6	261.3	-12%	204.5	-31%	179.6	-39%
Middle Upper Willow Creek	8,413	401.3	301.6	-25%	279.1	-30%	209.4	-48%
Lower Upper Willow Creek	12,344	788.0	569.6	-28%	535.3	-32%	386.8	-51%
Miners Gulch	6,998	64.9	55.1	-15%	62.4	-4%	53.0	-18%
Scotchman Gulch	3,963	42.3	33.7	-20%	34.3	-19%	27.5	-35%
Upper Willow Creek Total	**60,879**	**1863.3**	**1458.3**	**-22%**	**1294.3**	**-31%**	**1012.6**	**-46%**
Antelope Creek (Rock Mallard)	7,831	817.3	580.3	-29%	446.4	-45%	317.8	-61%
South Fork Antelope Creek	2,241	50.8	39.9	-22%	40.2	-21%	31.6	-38%
Antelope Creek Total	**10,072**	**868.1**	**620.1**	**-29%**	**486.6**	**-44%**	**349.5**	**-60%**
Quartz Gulch	1,632	25.6	20.2	-21%	24.7	-4%	19.5	-24%
Basin Gulch	492	11.0	8.7	-21%	9.2	-16%	7.4	-33%
Eureka Gulch	208	13.1	9.4	-28%	6.2	-53%	4.4	-66%
Eureka Gulch Total	**2,332**	**49.7**	**38.3**	**-23%**	**40.1**	**-19%**	**31.3**	**-37%**

Table F3-1. Summary of Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
		Upland Erosion Sediment Load for **Existing Conditions** and **Existing Riparian** Health (tons/year)	Upland Erosion Sediment Load for **BMP Conditions** and **Existing Riparian** Health (tons/year)	**Percent Change from Existing**	Upland Erosion Sediment Load for **Existing Conditions** and **BMP Riparian** Health (tons/year)	**Percent Change from Existing**	Upland Erosion Sediment Load for **BMP Conditions** and **BMP Riparian** Health (tons/year)	**Percent Change from Existing**
Brewster Creek	11,682	40.1	33.7	-16%	26.0	-35%	22.3	-44%
Flat Gulch	1,728	34.3	24.2	-29%	28.1	-18%	21.4	-37%
Sluice Gulch	5,453	529.8	379.2	-28%	294.6	-44%	211.4	-60%

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
West Fork Rock Creek Headwaters	Transitional	257	3.9	3.9	0%	3.5	-10%	3.5	-10%
	Evergreen Forest	10,423	73.5	73.5	0%	66.1	-10%	66.1	-10%
	Shrub/Scrub	528	52.9	35.4	-33%	47.9	-9%	32.3	-39%
	Herbaceous	1,736	67.3	55.8	-17%	58.8	-13%	49.0	-27%
	Woody Wetlands	1	0.0	0.0	0%	0.0	-4%	0.0	-4%
	Total	**12,944**	**197.5**	**168.7**	**-15%**	**176.4**	**-11%**	**150.9**	**-24%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Upper West Fork Rock Creek	Transitional	1,042	4.8	4.8	0%	4.2	-12%	4.2	-12%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	10,239	58.4	58.4	0%	52.8	-10%	52.8	-10%
	Shrub/Scrub	242	2.6	1.7	-33%	2.3	-11%	1.6	-40%
	Herbaceous	281	6.4	5.3	-17%	5.7	-12%	4.7	-26%
	Hay/Pasture	3	0.0	0.0	-35%	0.0	-19%	0.0	-47%
	Woody Wetlands	44	0.0	0.0	0%	0.0	-7%	0.0	-7%
	Total	**11,851**	**72.2**	**70.3**	**-3%**	**65.0**	**-10%**	**63.2**	**-12%**
Middle West Fork Rock Creek	Transitional	658	6.1	6.1	0%	5.5	-10%	5.5	-10%
	Open Water	10	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	101	3.5	3.5	0%	3.2	-9%	3.2	-9%
	Barren Land	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	10,446	112.6	112.6	0%	102.2	-9%	102.2	-9%
	Shrub/Scrub	765	127.1	85.2	-33%	112.2	-12%	75.6	-41%
	Herbaceous	98	1.2	1.0	-17%	1.0	-16%	0.8	-30%
	Woody Wetlands	4	0.0	0.0	0%	0.0	-17%	0.0	-17%
	Total	**12,084**	**250.5**	**208.4**	**-17%**	**224.1**	**-11%**	**187.3**	**-25%**
Lower West Fork Rock Creek	Transitional	3,025	42.9	42.9	0%	38.8	-10%	38.8	-10%
	Open Water	5	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	64	0.1	0.1	0%	0.1	-15%	0.1	-15%
	Barren Land	12	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	14,333	87.1	87.1	0%	79.7	-8%	79.7	-8%
	Shrub/Scrub	3,166	198.3	132.9	-33%	178.1	-10%	120.0	-39%
	Herbaceous	1,681	63.5	52.7	-17%	58.0	-9%	48.4	-24%
	Hay/Pasture	91	0.5	0.3	-35%	0.5	-7%	0.3	-40%
	Woody Wetlands	110	0.2	0.2	0%	0.2	-6%	0.2	-6%
	Total	**22,486**	**392.5**	**316.1**	**-19%**	**355.3**	**-9%**	**287.4**	**-27%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
West Fork Rock Creek Total	Transitional	4,983	57.6	57.6	0%	51.9	-10%	51.9	-10%
	Open Water	15	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	166	3.7	3.7	0%	3.3	-9%	3.3	-9%
	Barren Land	12	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	45,440	331.7	331.7	0%	300.9	-9%	300.9	-9%
	Shrub/Scrub	4,701	380.8	255.2	-33%	340.5	-11%	229.4	-40%
	Herbaceous	3,797	138.3	114.8	-17%	123.5	-11%	102.9	-26%
	Hay/Pasture	94	0.5	0.3	-35%	0.5	-7%	0.3	-40%
	Woody Wetlands	158	0.2	0.2	0%	0.2	-6%	0.2	-6%
	Total	**59,366**	**912.8**	**763.4**	**-16%**	**820.8**	**-10%**	**688.9**	**-25%**
East Fork Reservoir	Transitional	101	0.2	0.2	0%	0.1	-55%	0.1	-55%
	Open Water	301	0.0	0.0	0%	0.0	0%	0.0	0%
	Barren Land	303	0.8	0.8	0%	0.2	-77%	0.2	-77%
	Evergreen Forest	15,447	259.3	259.3	0%	132.5	-49%	132.5	-49%
	Shrub/Scrub	1,992	192.4	129.7	-33%	66.8	-65%	45.0	-77%
	Herbaceous	1,300	102.4	85.3	-17%	42.7	-58%	35.6	-65%
	Total	**19,443**	**555.0**	**475.2**	**-14%**	**242.3**	**-56%**	**213.3**	**-62%**
Meadow	Open Water	5	0.0	0.0	0%	0.0	0%	0.0	0%
	Barren Land	2	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	13,269	147.2	147.2	0%	68.9	-53%	68.9	-53%
	Shrub/Scrub	1,008	136.1	91.7	-33%	48.2	-65%	32.5	-76%
	Herbaceous	447	33.6	28.0	-17%	17.7	-47%	14.8	-56%
	Hay/Pasture	101	1.0	0.7	-35%	0.6	-46%	0.4	-65%
	Woody Wetlands	11	0.0	0.0	0%	0.0	-39%	0.0	-39%
	Total	**14,843**	**317.9**	**267.6**	**-16%**	**135.4**	**-57%**	**116.6**	**-63%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
East Fork Rock Creek	Transitional	103	2.0	2.0	0%	0.6	-69%	0.6	-69%
	Developed, Open Space	109	0.9	0.9	0%	0.4	-52%	0.4	-52%
	Developed, Low Intensity	28	0.2	0.2	0%	0.1	-38%	0.1	-38%
	Barren Land	3	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	6,224	79.4	79.4	0%	36.0	-55%	36.0	-55%
	Shrub/Scrub	6,066	692.9	466.8	-33%	321.7	-54%	216.7	-69%
	Herbaceous	2,713	80.9	67.4	-17%	36.5	-55%	30.4	-62%
	Hay/Pasture	1,062	6.5	4.2	-35%	3.7	-43%	2.4	-63%
	Woody Wetlands	59	0.1	0.1	0%	0.1	-32%	0.1	-32%
	Total	**16,367**	**862.9**	**621.1**	**-28%**	**399.1**	**-54%**	**286.8**	**-67%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
East Fork Rock Creek Total	Transitional	204	2.1	2.1	0%	0.7	-68%	0.7	-68%
	Open Water	306	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	109	0.9	0.9	0%	0.4	-52%	0.4	-52%
	Developed, Low Intensity	28	0.2	0.2	0%	0.1	-38%	0.1	-38%
	Barren Land	308	0.8	0.8	0%	0.2	-77%	0.2	-77%
	Evergreen Forest	34,940	485.9	485.9	0%	237.4	-51%	237.4	-51%
	Shrub/Scrub	9,066	1021.4	688.2	-33%	436.7	-57%	294.3	-71%
	Herbaceous	4,459	216.9	180.7	-17%	96.9	-55%	80.7	-63%
	Hay/Pasture	1,162	7.5	4.8	-35%	4.2	-43%	2.7	-64%
	Woody Wetlands	71	0.1	0.1	0%	0.1	-32%	0.1	-32%
	Total	**50,653**	**1735.8**	**1363.9**	**-21%**	**776.8**	**-55%**	**616.7**	**-64%**
Upper Willow Creek Headwaters	Transitional	1,450	16.9	16.9	0%	11.4	-33%	11.4	-33%
	Evergreen Forest	9,636	147.6	147.6	0%	97.0	-34%	97.0	-34%
	Shrub/Scrub	354	103.4	69.7	-33%	67.8	-34%	45.7	-56%
	Herbaceous	88	3.1	2.6	-17%	2.3	-27%	1.9	-39%
	Hay/Pasture	10	0.1	0.1	-35%	0.1	-35%	0.1	-58%
	Woody Wetlands	14	0.1	0.1	0%	0.0	-21%	0.0	-21%
	Total	**11,553**	**271.2**	**236.9**	**-13%**	**178.6**	**-34%**	**156.1**	**-42%**
Upper Upper Willow Creek	Transitional	4,632	58.3	58.3	0%	38.7	-34%	38.7	-34%
	Evergreen Forest	11,262	125.3	125.3	0%	84.6	-32%	84.6	-32%
	Shrub/Scrub	789	95.1	64.1	-33%	69.1	-27%	46.6	-51%
	Herbaceous	512	14.2	11.8	-17%	10.0	-29%	8.4	-41%
	Hay/Pasture	284	2.5	1.6	-35%	1.8	-28%	1.2	-53%
	Woody Wetlands	129	0.3	0.3	0%	0.3	-22%	0.3	-22%
	Total	**17,608**	**295.6**	**261.3**	**-12%**	**204.5**	**-31%**	**179.6**	**-39%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Middle Upper Willow Creek	Transitional	86	0.1	0.1	0%	0.0	-46%	0.0	-46%
	Evergreen Forest	3,053	39.0	39.0	0%	26.2	-33%	26.2	-33%
	Shrub/Scrub	2,959	243.4	164.0	-33%	170.3	-30%	114.7	-53%
	Herbaceous	2,037	116.1	96.8	-17%	80.6	-31%	67.2	-42%
	Hay/Pasture	277	2.7	1.7	-35%	1.9	-28%	1.3	-54%
	Woody Wetlands	1	0.0	0.0	0%	0.0	-36%	0.0	-36%
	Total	**8,413**	**401.3**	**301.6**	**-25%**	**279.1**	**-30%**	**209.4**	**-48%**
Lower Upper Willow Creek	Transitional	560	3.6	3.6	0%	2.5	-31%	2.5	-31%
	Developed, Open Space	59	0.8	0.8	0%	0.7	-17%	0.7	-17%
	Developed, Low Intensity	24	0.0	0.0	0%	0.0	-15%	0.0	-15%
	Barren Land	9	0.1	0.1	0%	0.0	-36%	0.0	-36%
	Evergreen Forest	2,189	31.1	31.1	0%	21.1	-32%	21.1	-32%
	Shrub/Scrub	4,985	580.5	391.2	-33%	395.2	-32%	266.3	-54%
	Herbaceous	4,162	170.1	141.7	-17%	114.5	-33%	95.4	-44%
	Hay/Pasture	357	1.7	1.1	-36%	1.3	-24%	0.8	-51%
	Total	**12,344**	**788.0**	**569.6**	**-28%**	**535.3**	**-32%**	**386.8**	**-51%**
Miners Gulch	Transitional	42	0.4	0.4	0%	0.4	-4%	0.4	-4%
	Evergreen Forest	6,606	34.5	34.5	0%	33.1	-4%	33.1	-4%
	Shrub/Scrub	315	29.4	19.7	-33%	28.4	-4%	19.1	-35%
	Herbaceous	34	0.6	0.5	-17%	0.5	-5%	0.5	-21%
	Hay/Pasture	0	0.0	0.0	-35%	0.0	-4%	0.0	-31%
	Total	**6,998**	**64.9**	**55.1**	**-15%**	**62.4**	**-4%**	**53.0**	**-18%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Scotchman Gulch	Transitional	190	0.3	0.3	0%	0.2	-20%	0.2	-20%
	Evergreen Forest	3,116	13.7	13.7	0%	11.4	-16%	11.4	-16%
	Shrub/Scrub	463	23.9	16.0	-33%	19.0	-21%	12.8	-47%
	Herbaceous	189	4.4	3.7	-17%	3.7	-16%	3.1	-30%
	Hay/Pasture	1	0.0	0.0	-35%	0.0	-16%	0.0	-46%
	Woody Wetlands	4	0.0	0.0	0%	0.0	-13%	0.0	-13%
	Total	**3,963**	**42.3**	**33.7**	**-20%**	**34.3**	**-19%**	**27.5**	**-35%**
Upper Willow Creek Total	Transitional	6,961	79.4	79.4	0%	53.2	-33%	53.2	-33%
	Developed, Open Space	59	0.8	0.8	0%	0.7	-17%	0.7	-17%
	Developed, Low Intensity	24	0.0	0.0	0%	0.0	-15%	0.0	-15%
	Barren Land	9	0.1	0.1	0%	0.0	-36%	0.0	-36%
	Evergreen Forest	35,863	391.2	391.2	0%	273.4	-30%	273.4	-30%
	Shrub/Scrub	9,866	1075.7	724.6	-33%	749.8	-30%	505.2	-53%
	Herbaceous	7,023	308.5	257.0	-17%	211.6	-31%	176.3	-43%
	Hay/Pasture	927	7.0	4.5	-35%	5.1	-27%	3.3	-53%
	Woody Wetlands	148	0.5	0.5	0%	0.4	-21%	0.4	-21%
	Total	**60,879**	**1863.3**	**1458.3**	**-22%**	**1294.3**	**-31%**	**1012.6**	**-46%**
Antelope Creek (Rock Mallard)	Transitional	330	9.8	9.8	0%	4.9	-50%	4.9	-50%
	Evergreen Forest	1,359	17.0	17.0	0%	8.3	-51%	8.3	-51%
	Shrub/Scrub	4,151	639.7	428.6	-33%	351.8	-45%	237.0	-63%
	Herbaceous	1,879	149.1	123.8	-17%	80.3	-46%	66.9	-55%
	Hay/Pasture	112	1.7	1.1	-35%	1.1	-37%	0.7	-59%
	Woody Wetlands	0	0.0	0.0	0%	0.0	-3%	0.0	-3%
	Total	**7,831**	**817.3**	**580.3**	**-29%**	**446.4**	**-45%**	**317.8**	**-61%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
South Fork Antelope Creek	Transitional	399	8.6	8.6	0%	6.8	-21%	6.8	-21%
	Evergreen Forest	1,155	8.6	8.6	0%	6.8	-21%	6.8	-21%
	Shrub/Scrub	505	32.7	21.9	-33%	26.0	-20%	17.6	-46%
	Herbaceous	182	0.9	0.8	-17%	0.6	-30%	0.5	-41%
	Total	**2,241**	**50.8**	**39.9**	**-22%**	**40.2**	**-21%**	**31.6**	**-38%**
Antelope Creek Total	Transitional	729	18.4	18.4	0%	11.6	-37%	11.6	-37%
	Evergreen Forest	2,514	25.6	25.6	0%	15.1	-41%	15.1	-41%
	Shrub/Scrub	4,656	672.4	450.5	-33%	377.8	-44%	254.6	-62%
	Herbaceous	2,061	150.0	124.5	-17%	81.0	-46%	67.5	-55%
	Hay/Pasture	112	1.7	1.1	-35%	1.1	-37%	0.7	-59%
	Woody Wetlands	0	0.0	0.0	0%	0.0	-3%	0.0	-3%
	Total	**10,072**	**868.1**	**620.1**	**-29%**	**486.6**	**-44%**	**349.5**	**-60%**
Quartz Gulch	Transitional	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Evergreen Forest	1,439	9.1	9.1	0%	8.8	-3%	8.8	-3%
	Shrub/Scrub	181	16.5	11.1	-33%	15.9	-4%	10.7	-35%
	Herbaceous	12	0.0	0.0	-17%	0.0	-15%	0.0	-29%
	Total	**1,632**	**25.6**	**20.2**	**-21%**	**24.7**	**-4%**	**19.5**	**-24%**
Basin Gulch	Evergreen Forest	452	4.1	4.1	0%	3.5	-15%	3.5	-15%
	Shrub/Scrub	39	6.9	4.6	-33%	5.7	-17%	3.9	-44%
	Herbaceous	1	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**492**	**11.0**	**8.7**	**-21%**	**9.2**	**-16%**	**7.4**	**-33%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Eureka Gulch	Developed, Open Space	1	0.0	0.0	0%	0.0	-59%	0.0	-59%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	-98%	0.0	-98%
	Evergreen Forest	179	1.9	1.9	0%	0.8	-58%	0.8	-58%
	Shrub/Scrub	26	11.1	7.5	-33%	5.3	-52%	3.6	-68%
	Hay/Pasture	0	0.0	0.0	-35%	0.0	-10%	0.0	-42%
	Woody Wetlands	2	0.0	0.0	0%	0.0	-28%	0.0	-28%
	Total	**208**	**13.1**	**9.4**	**-28%**	**6.2**	**-53%**	**4.4**	**-66%**
Eureka Gulch Total	Transitional	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Developed, Open Space	1	0.0	0.0	0%	0.0	-59%	0.0	-59%
	Developed, Low Intensity	0	0.0	0.0	0%	0.0	-98%	0.0	-98%
	Evergreen Forest	2,070	15.1	15.1	0%	13.1	-13%	13.1	-13%
	Shrub/Scrub	246	34.6	23.1	-33%	26.9	-22%	18.1	-47%
	Herbaceous	13	0.0	0.0	-17%	0.0	-15%	0.0	-29%
	Hay/Pasture	0	0.0	0.0	-35%	0.0	-10%	0.0	-42%
	Woody Wetlands	2	0.0	0.0	0%	0.0	-28%	0.0	-28%
	Total	**2,332**	**49.7**	**38.3**	**-23%**	**40.1**	**-19%**	**31.3**	**-37%**
Brewster Creek	Transitional	262	1.0	1.0	0%	0.5	-48%	0.5	-48%
	Developed, Open Space	3	0.0	0.0	0%	0.0	-31%	0.0	-31%
	Evergreen Forest	10,204	19.4	19.4	0%	14.0	-28%	14.0	-28%
	Shrub/Scrub	1,155	19.1	12.9	-33%	11.1	-42%	7.4	-61%
	Herbaceous	44	0.4	0.3	-17%	0.2	-39%	0.2	-49%
	Hay/Pasture	8	0.2	0.1	-35%	0.1	-17%	0.1	-46%
	Woody Wetlands	6	0.0	0.0	0%	0.0	-17%	0.0	-17%
	Total	**11,682**	**40.1**	**33.7**	**-16%**	**26.0**	**-35%**	**22.3**	**-44%**

Table F3-2. Delivered Sediment Load by Land Cover Type in the Rock Creek TPA

Subwatershed	Land Cover Classification	Area (acres)	Scenario 1	Scenario 2 (BMP 1)		Scenario 3 (BMP 2)		Scenario 4 (BMP 3)	
			Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Flat Gulch	Transitional	180	0.0	0.0	0%	0.0	-47%	0.0	-47%
	Evergreen Forest	968	4.5	4.5	0%	3.6	-21%	3.6	-21%
	Shrub/Scrub	394	19.3	12.9	-33%	16.0	-17%	10.8	-44%
	Herbaceous	186	10.4	6.8	-35%	8.5	-18%	7.1	-32%
	Woody Wetlands	0	0.0	0.0	0%	0.0	0%	0.0	0%
	Total	**1,728**	**34.3**	**24.2**	**-29%**	**28.1**	**-18%**	**21.4**	**-37%**
Sluice Gulch	Evergreen Forest	1,776	36.1	36.1	0%	20.0	-45%	20.0	-45%
	Shrub/Scrub	2,581	416.9	279.3	-33%	234.3	-44%	157.9	-62%
	Herbaceous	1,095	76.9	63.8	-17%	40.3	-48%	33.6	-56%
	Total	**5,453**	**529.8**	**379.2**	**-28%**	**294.6**	**-44%**	**211.4**	**-60%**

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ATTACHMENT F1 - NATIONAL LAND COVER DATABASE LAND COVER TYPE DESCRIPTIONS

11. Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.

21. Developed, Open Space - Includes areas with a mixture of constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

22. Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

31. Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.

42. Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

52. Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

71. Grasslands/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

ATTACHMENT F2 - ASSIGNMENT OF USLE C-FACTORS TO NLCD LAND COVER TYPES

TABLE 10.—*Factor C for permanent pasture, range, and idle land*[1]

Vegetative canopy		Cover that contacts the soil surface						
			Percent ground cover					
Type and height[2]	Percent cover[3]	Type[4]	0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.091	.043	.011
Tall weeds or short brush with average drop fall height of 20 in	25	G	.36	.17	.09	.038	.013	.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, with average drop fall height of 6½ ft	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush. Average drop fall height of 13 ft	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

[1] The listed **C** values assume that the vegetation and mulch are randomly distributed over the entire area.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 in deep.

W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

C-Factors for land cover types in the Rock TPA for Existing Conditions

NLCD Code	Description	Type and Height of Raised Canopy	Percent Canopy Cover	Type	Percent Ground Cover	C-Factor
11*	Open Water	-	-	-	-	-
21	Developed, Open Space	no appreciable canopy	-	G	95-100	0.003
22	Developed, Low Intensity	-	-	-	-	0.001
31	Barren Land	-	-	-	-	0.001
42	Evergreen Forest	trees	75	G	95-100	0.003
52	Shrub/Scrub	appreciable brush	25	G	55	0.046
71	Grassland/Herbaceous	no appreciable canopy	-	G	55	0.042
81	Hay/Pasture	no appreciable canopy	-	G	75	0.020
90	Woody Wetlands	trees	25	G	95-100	0.003

*Water Land Classes will not be counted as surfaces contributing erosion

NLCD Code	**Description**	**Type and Height of Raised Canopy**				
11*	Open Water	-				
21	Developed, Open Space	no appreciable canopy				
22	Developed, Low Intensity	-				
31	Barren Land	-				
42	Evergreen Forest	trees				
52	Shrub/Scrub	appreciable brush				
71	Grassland/Herbaceous	no appreciable canopy				
81	Hay/Pasture	no appreciable canopy				
90	Woody Wetlands	trees				