APPENDIX C
SEDIMENT CONTRIBUTION FROM HILLSLOPE EROSION IN THE MIDDLE AND LOWER BIG HOLE WATERSHED

Introduction

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE), and sediment delivery to the stream was predicted using a sediment delivery ratio. This model provided an assessment of existing sediment loading from upland sources and an assessment of potential sediment loading through the application of Best Management Practices (BMPs). For this evaluation, the primary BMP evaluated includes the modification in upland management practices. When reviewing the results of the upland sediment load model it is important to note that a significant portion of the remaining sediment loads after BMPs in areas with grazing and/or silvicultural land-uses is also a component of the “natural upland load”. However, the assessment methodology didn’t differentiate between sediment loads with all reasonable BMPs and “natural” loads.

A list of land cover classifications used in the USLE model is presented in **Table C-1**, along with a description of which land-use was associated with each cover type for the purposes of sediment source assessment and load allocations.

Table C-1. Land Cover Classifications for the USLE Model.

Land Cover Classifications	Land-use / Sediment Source
Bare Rock/Sand/Clay	Natural Source
Deciduous Forest	Natural Source
Evergreen Forest	Natural Source
Mixed Forest	Natural Source
Woody Wetlands	Natural Source
Logging	Silviculture
Grasslands/Herbaceous	Grazing
Shrubland	Grazing
Pasture/Hay	Cropland
Small Grains	Cropland

Universal Soil Loss Equation (USLE)

The general form of the USLE has been widely used for erosion prediction in the U.S. and is presented in the National Engineering Handbook (1983) as:

$$A = RK(LS)CP \text{ (in tons acre}^{-1}\text{ year}^{-1}\text{)}$$

where soil loss (A) is a function of the rainfall erosivity index (R), soil erodibility factor (K), overland flow slope and length (LS), crop management factor (C), and conservation practice factor (P) (Wischmeier and Smith 1978, Renard et al. 1991). The USLE estimates average soil loss from sheet and rill erosion but does not estimate soil loss from gully erosion. USLE was selected for the Middle and Lower Big Hole watershed due to its relative simplicity, ease in parameterization, and the fact that it has been integrated into a number of other erosion prediction models. These include: (1) the Agricultural Nonpoint Source Model (AGNPS), (2) Areal Nonpoint Source Watershed Environment Response Simulation Model (ANSWERS), (3) Erosion Productivity Impact Calculator (EPIC), (4) Generalized Watershed Loading Functions (GWLF), and (5) the Soil Water Assessment Tool (SWAT) (Doe, 1999). A detailed description of the general USLE model parameters is presented below.

The **R-factor** is an index that characterizes the effect of raindrop impact and rate of runoff associated with a rainstorm. It is a summation of the individual storm products of the kinetic energy in rainfall (hundreds of ft-tons acre-1 year-1) and the maximum 30-minute rainfall intensity (inches hour-1). The total kinetic energy of a storm is obtained by multiplying the kinetic energy per inch of rainfall by the depth of rainfall during each intensity period.

The **K-factor,** or soil erodibility factor, indicates the susceptibility of soil to resist erosion. It is derived by the measurement of soil particle size (texture), percent organic matter, structure, and permeability. It is a measure of the average soil loss (tons acre-1 hundreds of ft-tons-1 per acre of rainfall intensity) from a particular soil in continuous fallow. The K-factor is based on experimental data from the standard Soil Conservation Service (SCS) erosion plot that is 72.6 ft long with a uniform slope of 9 percent.

The **LS-factor** is a function of the slope and overland flow length of the eroding slope or cell. For the purpose of computing the LS-value, slope is defined as the average land surface gradient. The flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. According to McCuen, (1998), flow lengths are seldom greater than 400 or shorter than 20 feet.

The **C-factor** or crop management factor is the ratio of the soil eroded from a specific type of cover to that from a clean-tilled fallow under identical slope and rainfall. It integrates a number of factors that effect erosion, including vegetative cover, plant litter, soil surface, and land management. The original C-factor of the USLE was experimentally determined for agricultural crops and has since been modified to include rangeland and forested cover. It is now referred to as the vegetation management factor (VM) for non-agricultural settings (Brooks, 1997).

Three different kinds of effects are considered in determination of the VM-factor. These include: (1) canopy cover effects, (2) effects of low-growing vegetal cover, mulch, and litter, and (3) rooting structure. A set of metrics has been published by the Soil Conservation Service (SCS) for estimation of the VM-factors for grazed and undisturbed woodlands, permanent pasture, rangeland, and idle land. Although these are quite helpful for the Middle and Lower Big Hole watershed, Brooks (1997) cautions that more work has been carried out in determining the agriculturally based C-factors rather than rangeland/forest VM-factors. Because of this, the results of the interpretation should be used with discretion.

The **P-factor** (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 (up-slope down-slope) farming practices with that of certain agriculturally-based conservation practices.

Modeling Approach
Sediment delivery from hillslope erosion was estimated using a Universal Soil Loss Equation (USLE) based model to predict soil loss, along with a sediment delivery ratio (SDR) to predict sediment delivered to the stream. This USLE based model is implemented as a watershed scale grid format, GIS model using ArcView v 9.0 GIS software.

Desired results from the modeling effort include the following: (1) annual sediment load from each of the water quality limited segments on the state's 303(d) List, and (2) the mean annual source distribution from each land category type. Based on these considerations, a GIS-modeling approach (USLE 3-D) was formulated to facilitate database development and manipulation, provide spatially explicit output, and supply output display for the modeling effort.

Modeling Scenarios
Two upland management scenarios were proposed as part of the Middle and Lower Big Hole River modeling project. They include: (1) an existing condition scenario that considers the current land use cover and management practices in the watershed and (2) an improved grazing and cover management scenario.

Erosion was differentiated into two source categories for each scenario: (1) natural erosion that occurs on the time scale of geologic processes and (2) anthropogenic erosion that is accelerated by human-caused activity. A similar classification is presented as part of the National Engineering Handbook Chapter 3 - Sedimentation (USDA, 1983). Differentiation is necessary for TMDL planning.

Data Sources
The USLE-3D model was parameterized using a number of published data sources. These include information from: (1) USGS, (2) Spatial Climate Analysis Service (SCAS), and (3) Soil Conservation Service (SCS). Additionally, local information regarding specific land use management and cropping practices was acquired from the Montana Agricultural Extension Service and the Natural Resource Conservation Service (NRCS). Specific GIS coverages used in the modeling effort included the following:

<u>R – Rainfall factor</u>. Grid data of this factor was obtained from the NRCS, and is based on Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation data. PRISM precipitation data is derived from weather station precipitation records, interpolated to a gridded landscape coverage by a method (developed by the Spatial Climate Analysis Service of Oregon State University) which accounts for the effects of elevation on precipitation patterns.

<u>K – Soil erodibility factor</u>. Polygon data of this factor were obtained from the NRCS General Soil Map (STATSGO) database. The USLE K factor is a standard component of the STATSGO soil survey. STATSGO soils polygon data were summarized and interpolated to grid format for this analysis.

LS – Slope length and slope factors. These factors were derived from 30m USGS digital elevation model (DEM) grid data, interpolated to a 10m pixel.

C – Cropping factor. This factor was estimated using the National Land Cover Dataset (NLCD), using C-factor interpretations provided by the NRCS and refined by Montana DEQ using SCS C-factor tables (Brooks et al. 1997). C-factors are intended to be conservatively representative of conditions in the Middle and Lower Big Hole valley.

P – Management practices factor. This factor was set to 1, as consultation with the NRCS State Agronomist suggests that this value is the most appropriate representation of current management practices in the Middle and Lower Big Hole valley (i.e. no use of contour plowing, terracing, etc).

Method

An appropriate grid for each factors' values was created, giving full and appropriate consideration to proper stream network delineation, grid cell resolution, etc. A computer model was built using ArcView Model Builder to derive the five factors from model inputs, multiply the five factors and arrive at a predicted sediment production for each grid cell. The model also derived a sediment delivery ratio for each cell, and reduced the predicted sediment production by that factor to estimate sediment delivered to the stream network.

Specific parameterization of the USLE factors were performed as follows:

Middle and Lower Big Hole DEM

The digital elevation model (DEM) for the Middle and Lower Big Hole watershed was the foundation for developing the LS factor, for defining the extent of the bounds of the analysis area (the Middle and Lower Big Hole watershed), and for delineating the area within the outer bounds of the analysis for which the USLE model is not valid (i.e. the concentrated flow channels of the stream network). The USGS 30m DEM (level 2) for the Middle and Lower Big Hole was used for these analyses. First the DEM was interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Middle and Lower Big Hole watershed streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m was then subjected to standard hydrologic preprocessing, including the filling of sinks to create a positive drainage condition for all areas of the watershed.

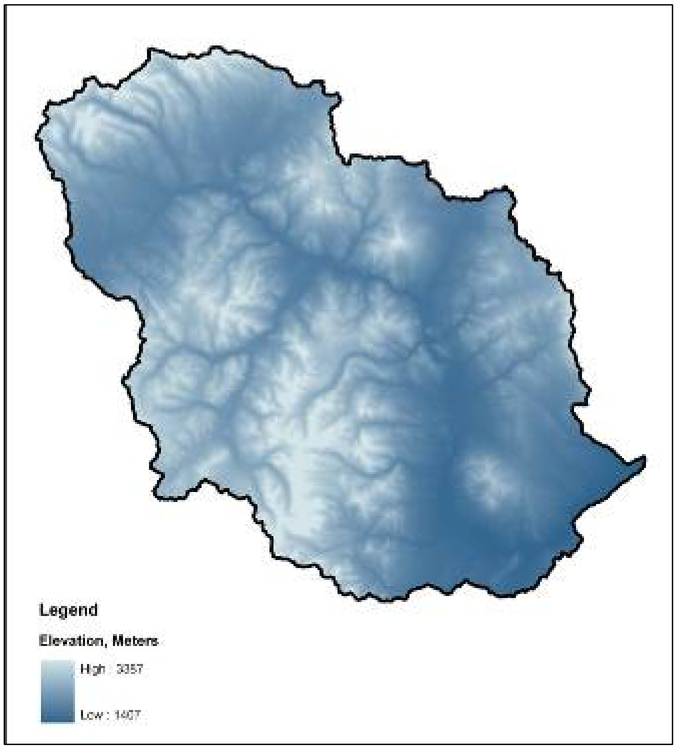

Figure C-1. Digital Elevation Model (DEM) of the Middle and Lower Big Hole watershed, prepared for hydrologic analysis.

R-Factor

The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service of Oregon State University at 4 km grid cell resolution. For the purposes of this analysis, the SCAS R-factor grid was reprojected to Montana State Plane Coordinates (NAD83, meters), resampled to a 10m analytic cell size and clipped to the extent of the Middle and Lower Big Hole watershed, to match the project's standard grid definition.

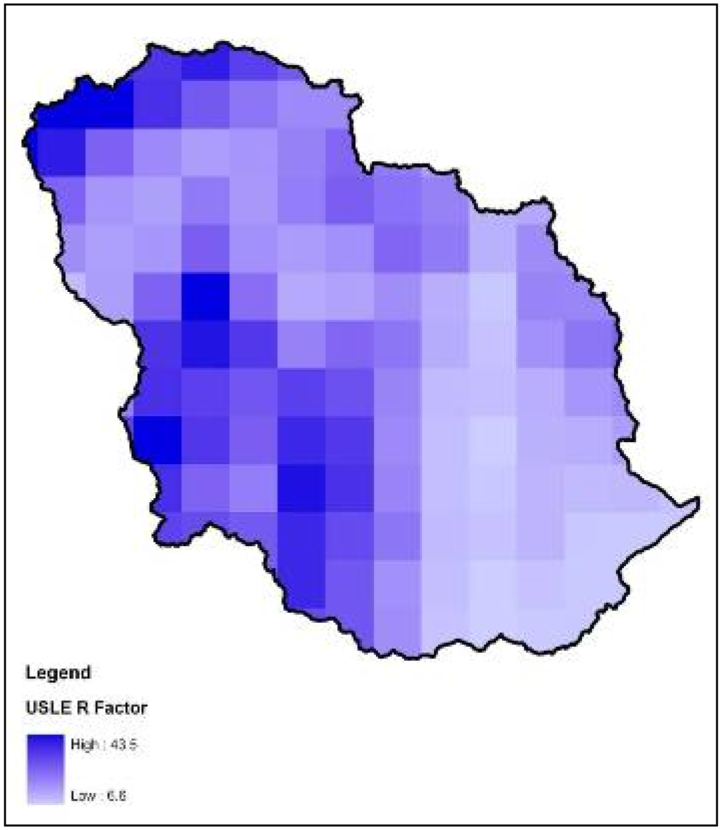

Figure C-2. ULSE R factor for the Middle and Lower Big Hole Watershed.

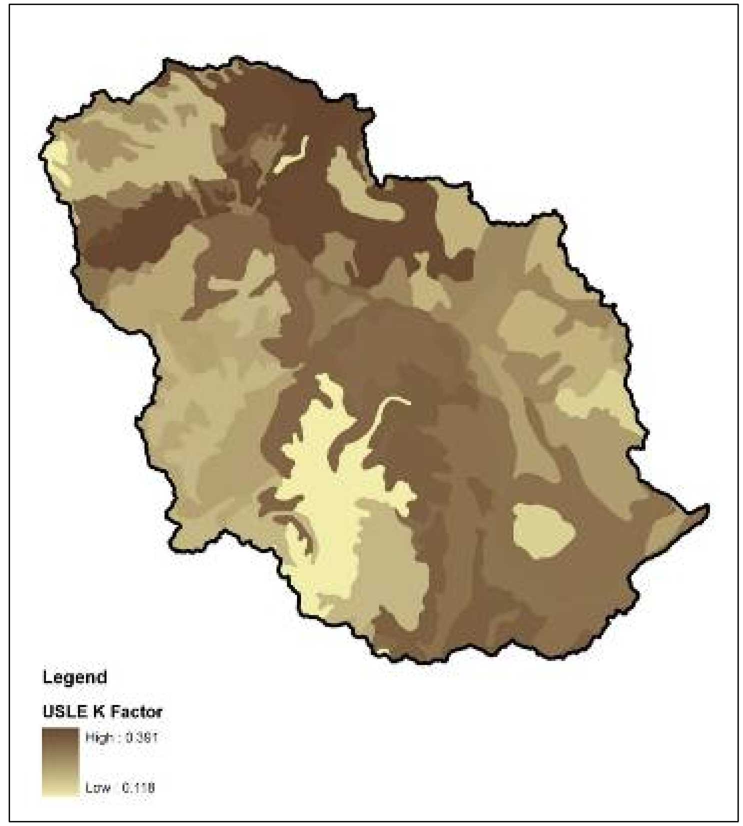

Figure C-3. ULSE K factor for the Middle and Lower Big Hole Watershed.

The soil erodibility factor grid was compiled from 1:250K STATSGO data, as published by the NRCS. STATSGO database tables were queried to calculate a component weighted K value for all surface layers, which was then summarized by individual map unit. The map unit K values were then joined to a GIS polygon coverage of the STATSGO map units, and the polygon coverage was converted to a 10m analytic grid for use in this analysis.

LS- Factor

The equation used for calculating the slope length and slope factor was that given in the updated definition of USLE, as published in USDA handbook #537:

$$LS = (\lambda/72.6)^m (65.41 \sin^2\theta + 4.56 \sin\theta + 0.065)$$

Where:

λ = slope length in feet. This value was determined by applying GIS based surface analysis procedures to the Middle and Lower Big Hole watershed DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters. In accordance with research that indicates that, in practice, the slope length rarely exceeds 400 ft, λ was limited to that maximum value.

θ = cell slope as calculated by GIS based surface analysis procedures from the Middle and Lower Big Hole watershed DEM

m = 0.5 if percent slope of the cell >= 5
= 0.4 if percent slope of the cell >= 3.5 AND < 5
= 0.3 if percent slope of the cell >= 1 AND < 3.5
= 0.2 if percent slope of the cell < 1

The LS factor grid was calculated from individual grids computed for each of these sub factors, using a simple ArcView Model Builder script.

C-Factor

The cover management factor of the USLE reflects the varying degree of erosion protection that results from different cover types. It integrates a number of factors including vegetative cover, plant litter, soil surface, and land management. For the purpose of this study, the C-factor is the only USLE parameter that can be altered by the influence of human activity. Based on this, C-factors were estimated for the existing condition and improved management scenarios (**Table C-2**). The C-factor change for agricultural cover types between management scenarios corresponds to increases in the percent of land cover that are achievable through the application of various best management practices (**Table C-3**). For natural sources (i.e. bare rock, deciduous forest, and evergreen forest), the C-factor is the same for both scenarios. A C-factor slightly higher than a deciduous/evergreen forest was used for logged areas because logging intensity within the watershed is generally low and because practices, such as riparian clear-cutting, that tend to produce high sediment yields have not been used since at least 1991, when the MT Streamside Management Zone (SMZ) law was enacted. Additionally, the USLE model is intended to reflect long-term average sediment yield, and while a sediment pulse typically occurs in the first year after logging, sediment production after the first year rapidly declines (Rice et al. 1972; Elliot and Robichaud 2001; Elliot 2006). The logging C-factor is the same for both management scenarios to indicate that logging will continue sporadically on public and private land within the watershed and will produce sediment at a rate slightly higher than an undisturbed forest. This is not intended to imply that additional best management practices beyond those in the SMZ law should not be used for logging activities.

C-factors were defined spatially through use of a modified version of the Anderson land cover classification (1976) and the 1992 30m Landsat Thematic Mapper (TM) multi-spectral imaging National Land Cover Data (NLCD), 1992) (**Figure-4**). C-factor values were assigned globally to each land type and range from 0.001 to 1.0. These data were re-projected to Montana State plane projection/coordinate system, and resampled to the standard 10m grid. No field efforts were initiated as part of this study to refine C-factor estimation for the watershed.

Table C-2. Middle and Lower Big Hole River C-Factor; Existing and improved management conditions.

NLCD Code	Description	C-Factor	
		Existing Condition	Improved Management Condition
		0.001	0.001
41	Deciduous Forest	0.003	0.003
42	Evergreen Forest	0.003	0.003
43	Mixed Forest	0.003	0.003
91	Woody Wetlands	0.0001	0.0001
51	Shrubland	0.046	0.031
71	Grasslands Herbaceous	0.042	0.035
81	Pasture /Hay	0.020	0.013
83	Small Grains	0.240	0.015
N/A	Logging	0.006	0.006

Table C-3. Changes in percent ground cover for agricultural land cover types between existing and improved management conditions.

Land Cover	Existing % ground cover	Improved % ground cover
Shrubland	55	65
Grasslands Herbaceous	55	65
Pasture /Hay	65	75
Small Grains	20	40

NLCD – Land cover

In general, the land use classification of the NLCD was accepted as is, without ground truthing of original results or correction of changes over the time since the NLCD image was taken. Given that we are looking for watershed and subwatershed scale effects, this was considered to be a reasonable assumption. Given the relative simplicity of the land use mix in the Big Hole valley, and the relative stability of that land use over the 14 years since the Landsat image that the NLCD is based on was shot. One adjustment was made to the NLCD, however. That adjustment was to quantify the amount of logging that has occurred since 1992, and to also identify areas that are reforesting over that same period. As with other land uses in the valley, logging is a stable land use, but it is a land use that causes a land cover change that may effect sediment production.

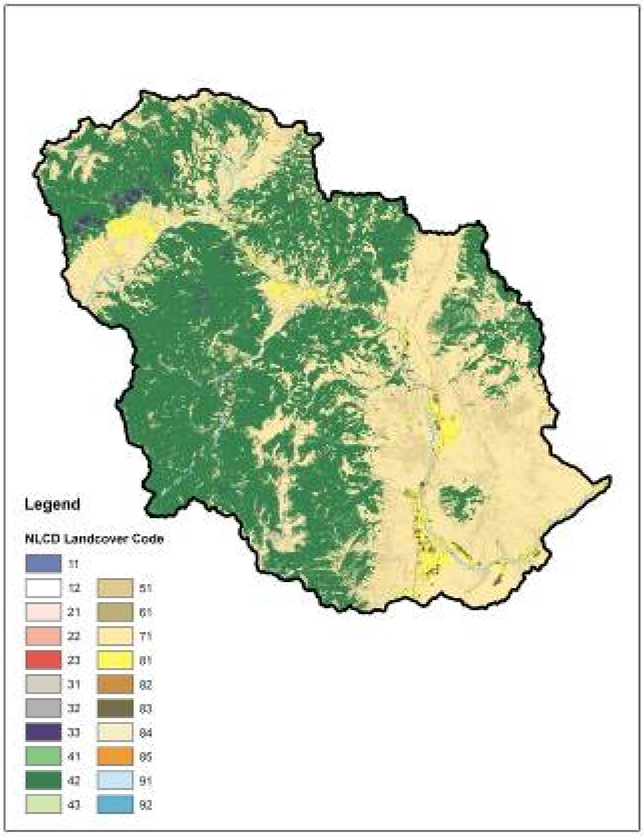

Figure C-4. NLCD Landcover for the Middle and Lower Big Hole Watershed.

Adjustment for logging and reforestation was accomplished by comparing the 1992 NLCD grid for the Middle and Lower Big Hole watershed with the 2005 National Agriculture Imagery Program (NAIP) aerial photography. Areas which were coded as a forest type (41 or 42) on the NLCD were recoded to 'logged' if:

- They appeared to be otherwise (typically bare ground, grassland, or shrubland) on the NAIP photos, and
- There were indications of indicated logging activity (proximity to forest or logging roads, appearance of stands, etc).

Sediment Delivery Ratio

A sediment delivery ratio (SDR) factor was created for each grid cell, based on the relationship between the distance from the delivery point to the stream established by Dube, Megahan & McCalmon in their development of the Washington Road Surface Erosion Model (WARSEM). This relationship was developed by integrating the results of several previous studies (principally those of Megehan and Ketchison) which examined sediment delivery to streams downslope of forest roads. They found that the proportion of sediment production that is ultimately delivered to streams declines with distance from the stream (**Table C-4**) with the balance of the sediment being deposited between the point of production and the stream. We believe the use of this relationship to develop a SDR for a USLE based model is a conservative (i.e. tending toward the high end of the range of reasonable values) estimate of sediment delivery from hillslope erosion, especially in light of the fact that the USLE methodology does not account for gully erosion. The SDR factor was applied to the results of the USLE model to estimate sediment delivered from hill slope sources, by calculating the distance from each cell to the nearest stream channel, and multiplying the sediment production of that cell by the corresponding distance based percentage of delivery.

Table C-4. The percent of sediment delivered by distance from a water body.

Distance from Culvert (ft)	Percent of Total Eroded Sediment Delivered
0	100
35	70
70	50
105	35
140	25
175	18
210	10
245	4
280	3
315	2
350	1

Although the SDR factor accounts for the distance of sediment production cells from the stream channel, it does not account for riparian condition and the ability of riparian vegetation to filter out sediment and prevent it from entering the stream. Depending on the vegetation type and buffer width, healthy riparian buffers can remove anywhere from 50-90 percent of sediment (Castelle and Johnson 2000; Hook 2003; DEQ 2007). Therefore, the USLE model used for source assessment may have overestimated existing loads and underestimated potential reductions due to hillslope erosion.

Results

Figures C-5 and **C-6** present the USLE based hillslope model's prediction of existing and potential conditions graphically for the Middle and Lower Big Hole watershed. **Table C-5** contains the estimated existing and potential sediment load from hillslope erosion for the Middle and Lower Big Hole watershed and broken out by the 6th code HUC and existing land cover type. Note, because of the HUC-6 scale, the loads for French and Deep creeks are not cumulative for those watersheds and differ from the cumulative loads presented in the document.

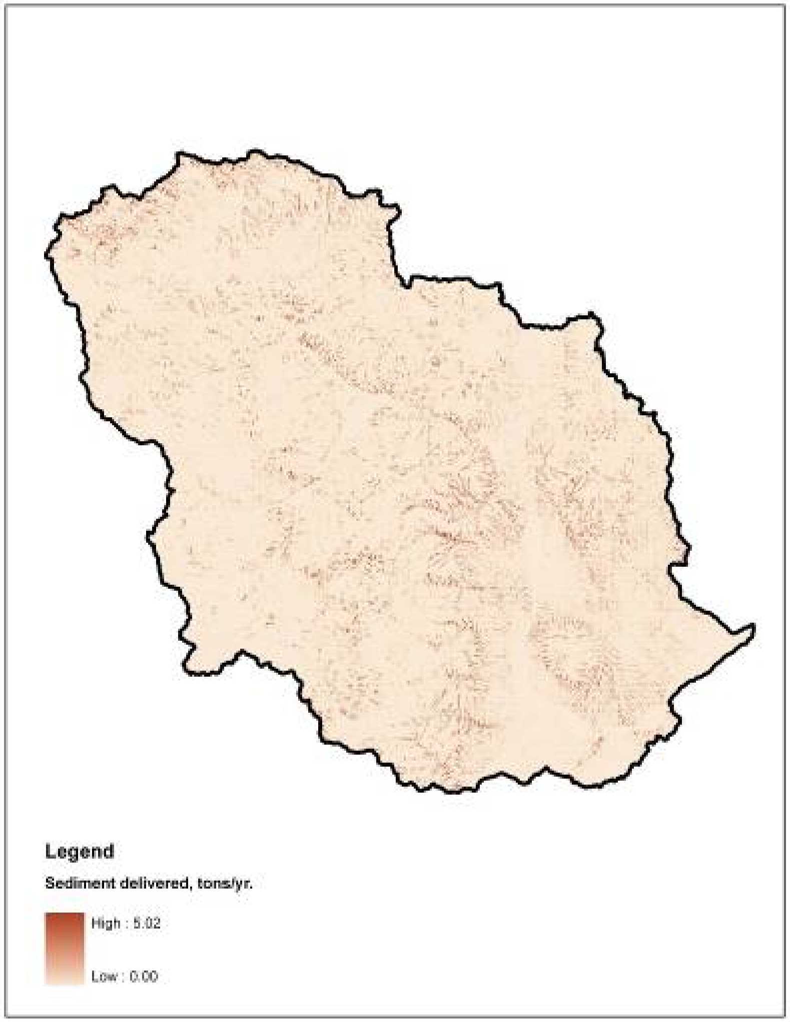

Figure C-5. Estimated sediment delivery from hill slopes, existing conditions.

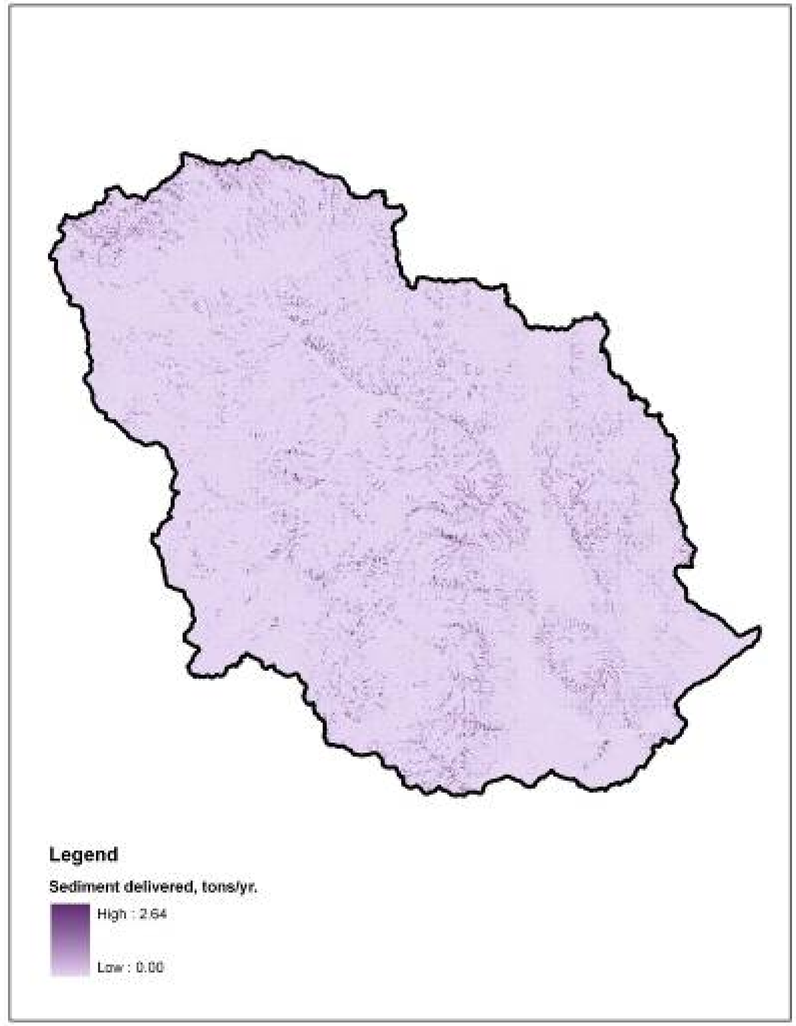

Figure C-6. Estimated sediment delivery from hill slopes, BMP conditions.

Table C-5. Total and normalized existing and potential sediment loads from upland erosion for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). The Middle and Lower Big Hole watershed is bolded.

6th Code HUC Subwatershed	Acres	Existing Load (tons/yr)	Potential Load (tons/yr)	Normalized Existing Load (tons/acre/yr)	Normalized Potential Load (tons/acre/yr)
Alder Creek	13256	351	314	0.026	0.024
American Creek	4252	261	212	0.061	0.050
Big Hole River-Biltmore Hot Springs	21813	1400	1087	0.064	0.050
Big Hole River-Brownes Gulch	17961	1037	799	0.058	0.044
Big Hole River-Dewey	20878	2200	1733	0.105	0.083
Big Hole River-Dickie Bridge	15620	1636	1271	0.105	0.081
Big Hole River-Fishtrap	29976	1361	1107	0.045	0.037
Big Hole River-Lost Creek	11874	769	599	0.065	0.050
Big Hole River-Meadow Creek	22893	1339	1077	0.059	0.047
Big Hole River-Melrose	14465	1133	863	0.078	0.060
Big Hole River-Quartz Hill Gulch	23492	1815	1469	0.077	0.063
Big Hole River-Squaw Creek	18764	514	416	0.027	0.022
Big Hole River-Stevens Slough	19568	1124	868	0.057	0.044
Big Hole River-Twin Bridges	22725	969	769	0.043	0.034
Birch Creek	32726	2250	1760	0.069	0.054
Bryant Creek	11787	536	465	0.045	0.039
California Creek	8889	616	492	0.069	0.055
Camp Creek	19700	1770	1413	0.090	0.072
Canyon Creek	31065	4193	3382	0.135	0.109
Charcoal Gulch	1596	134	109	0.084	0.068
Cherry Creek	11275	1232	995	0.109	0.088
Corral Creek	3377	285	227	0.084	0.067
Deep Creek	22337	2074	1659	0.093	0.074
Delano Creek	1284	118	97	0.092	0.075
Elkhorn Creek	7149	318	261	0.044	0.037
Fishtrap Creek	31604	2537	2066	0.080	0.065
French Creek	12532	616	509	0.049	0.041
Gold Creek	4813	654	535	0.136	0.111
Grose Creek	1899	124	101	0.065	0.053
Headwaters Wise River	23606	1126	909	0.048	0.039
Jerry Creek	27376	1692	1412	0.062	0.052
Lacy Creek	11183	297	255	0.027	0.023
LaMarche Creek	30732	3979	3256	0.129	0.106
Lost Creek	4967	615	495	0.124	0.100
Lower Divide Creek	15553	730	591	0.047	0.038

Table C-5. Total and normalized existing and potential sediment loads from upland erosion for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). The Middle and Lower Big Hole watershed is bolded.

6th Code HUC Subwatershed	Acres	Existing Load (tons/yr)	Potential Load (tons/yr)	Normalized Existing Load (tons/acre/yr)	Normalized Potential Load (tons/acre/yr)
Lower Pattengail Creek	12669	672	543	0.053	0.043
Lower Willow Creek	19556	1549	1166	0.079	0.060
Lower Wise River	15849	729	611	0.046	0.039
McCartney Creek	12875	869	684	0.068	0.053
Mclean Creek	2095	134	105	0.064	0.050
Middle Pattengail Creek	15254	306	277	0.020	0.018
Middle Wise River	19615	1615	1314	0.082	0.067
Moose Creek	25871	1246	986	0.048	0.038
Mudd Creek	9822	194	164	0.020	0.017
Nez Perce Creek	14031	507	406	0.036	0.029
North Fork Divide Creek	18537	493	420	0.027	0.023
Oregon Creek	1314	128	103	0.098	0.078
Rochester Creek	21414	1209	953	0.056	0.045
Rock Creek	22414	1689	1333	0.075	0.059
Sassman Gulch	3487	266	207	0.076	0.059
Sawlog Creek	3926	262	224	0.067	0.057
Seven Springs Creek	3648	219	165	0.060	0.045
Sevenmile Creek	2863	335	269	0.117	0.094
Seymour Creek	20527	1902	1526	0.093	0.074
Sixmile Creek	2843	381	307	0.134	0.108
Soap Gulch	5768	822	650	0.142	0.113
Squaw Creek	12887	363	324	0.028	0.025
Trapper Creek	25610	2604	2058	0.102	0.080
Twelvemile Creek	5883	754	613	0.128	0.104
Upper Divide Creek	22932	1019	834	0.044	0.036
Upper Pattengail Creek	16803	452	398	0.027	0.024
Upper Willow Creek	22066	1161	936	0.053	0.042
Upper Wise River	16058	993	801	0.062	0.050
Wickiup Creek	3891	281	228	0.072	0.059
Wyman Creek	18298	303	266	0.017	0.015
Middle and Lower Big Hole Watershed	**971797**	**65260**	**52444**	**0.067**	**0.054**

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Alder Creek	Evergreen Forest	207	207
	Grasslands/Herbaceous	44	37
	Shrubland	93	63
	Logging	7	7
*Alder Creek Total		351	314
American Creek	Evergreen Forest	53	53
	Grasslands/Herbaceous	119	99
	Shrubland	89	60
*American Creek Total		261	212
Big Hole River-Biltmore Hot Springs	Grasslands/Herbaceous	1001	834
	Pasture/Hay	5	3
	Shrubland	369	249
	Small Grains	25	2
Big Hole River-Biltmore Hot Springs Total		1,400	1,087
Big Hole River-Brownes Gulch	Evergreen Forest	20	20
	Grasslands/Herbaceous	712	593
	Pasture/Hay	16	10
	Shrubland	257	173
	Small Grains	31	2
Big Hole River-Brownes Gulch Total		1,037	799
Big Hole River-Dewey	Evergreen Forest	184	184
	Grasslands/Herbaceous	1269	1058
	Pasture/Hay	4	3
	Shrubland	723	487
	Small Grains	19	1
*Big Hole River-Dewey Total		2,200	1,733
Big Hole River-Dickie Bridge	Evergreen Forest	201	201
	Grasslands/Herbaceous	821	684
	Logging	12	12
	Pasture/Hay	22	14
	Shrubland	529	356
	Small Grains	52	3
*Big Hole River-Dickie Bridge Total		1,636	1,270

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Big Hole River-Fishtrap	Evergreen Forest	230	230
	Grasslands/Herbaceous	757	631
	Logging	5	5
	Pasture/Hay	68	44
	Shrubland	293	197
	Small Grains	9	1
*Big Hole River-Fishtrap Total		1,361	1,107
Big Hole River-Lost Creek	Evergreen Forest	22	22
	Grasslands/Herbaceous	508	423
	Pasture/Hay	7	4
	Shrubland	222	149
	Small Grains	11	1
Big Hole River-Lost Creek Total		769	599
Big Hole River-Meadow Creek	Evergreen Forest	237	237
	Grasslands/Herbaceous	648	540
	Pasture/Hay	28	18
	Shrubland	418	282
	Small Grains	8	1
*Big Hole River-Meadow Creek Total		1,339	1,077
Big Hole River-Melrose	Evergreen Forest	5	5
	Grasslands/Herbaceous	661	551
	Pasture/Hay	4	3
	Shrubland	452	304
	Small Grains	12	1
Big Hole River-Melrose Total		1,133	863
*Big Hole River-Quartz Hill Gulch	Evergreen Forest	368	368
	Grasslands/Herbaceous	796	664
	Logging	3	3
	Pasture/Hay	13	8
	Shrubland	633	426
	Small Grains	2	0
Big Hole River-Quartz Hill Gulch Total		1,815	1,469

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Big Hole River-Squaw Creek	Evergreen Forest	38	38
	Grasslands/Herbaceous	341	284
	Logging	9	9
	Pasture/Hay	4	3
	Shrubland	122	82
*Big Hole River-Squaw Creek Total		514	416
Big Hole River-Stevens Slough	Evergreen Forest	3	3
	Grasslands/Herbaceous	769	641
	Pasture/Hay	7	5
	Shrubland	325	219
	Small Grains	21	1
Big Hole River-Stevens Slough Total		1,124	868
Big Hole River-Twin Bridges	Evergreen Forest	3	3
	Grasslands/Herbaceous	757	631
	Pasture/Hay	2	1
	Shrubland	198	134
	Small Grains	9	1
Big Hole River-Twin Bridges Total		969	769
Birch Creek	Bare Rock/Sand/Clay	2	2
	Evergreen Forest	278	278
	Grasslands/Herbaceous	1,022	851
	Pasture/Hay	9	6
	Shrubland	922	621
	Small Grains	17	1
Birch Creek Total (lower)		2,250	1,760
Bryant Creek	Evergreen Forest	227	227
	Grasslands/Herbaceous	157	131
	Logging	15	15
	Shrubland	137	92
*Bryant Creek Total		536	465
California Creek	Evergreen Forest	38	38
	Grasslands/Herbaceous	403	336
	Shrubland	175	118
*California Creek Total		616	492

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Camp Creek	Evergreen Forest	102	102
	Grasslands/Herbaceous	1,191	993
	Pasture/Hay	2	1
	Shrubland	469	316
	Small Grains	4	0
	Woody Wetlands	1	1
Camp Creek Total		1,770	1,413
Canyon Creek	Evergreen Forest	312	312
	Grasslands/Herbaceous	2,851	2,376
	Logging	1	1
	Shrubland	1,028	693
Canyon Creek Total		4,193	3,382
Charcoal Gulch	Evergreen Forest	19	19
	Grasslands/Herbaceous	77	65
	Shrubland	37	25
*Charcoal Gulch Total		134	109
Cherry Creek	Evergreen Forest	124	124
	Grasslands/Herbaceous	781	651
	Shrubland	327	221
Cherry Creek Total		1,232	995
Corral Creek	Evergreen Forest	22	22
	Grasslands/Herbaceous	163	136
	Logging	4	4
	Shrubland	96	65
*Corral Creek Total		285	227
Deep Creek	Bare Rock/Sand/Clay	2	2
	Evergreen Forest	122	122
	Grasslands/Herbaceous	1,363	1,136
	Logging	7	7
	Pasture/Hay	2	1
	Shrubland	578	390
	Woody Wetlands	1	1
*Deep Creek Total		2,074	1,659
Delano Creek	Evergreen Forest	10	10
	Grasslands/Herbaceous	88	73
	Shrubland	20	14
*Delano Creek Total		118	97
Elkhorn Creek	Evergreen Forest	88	88

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
	Grasslands/Herbaceous	113	94
	Logging	1	1
	Shrubland	117	79
*Elkhorn Creek Total		318	261
Fishtrap Creek	Bare Rock/Sand/Clay	1	1
	Deciduous Forest	1	1
	Evergreen Forest	383	383
	Grasslands/Herbaceous	1,466	1,222
	Logging	5	5
	Pasture/Hay	27	18
	Shrubland	644	434
	Small Grains	8	1
	Woody Wetlands	1	1
*Fishtrap Creek Total		2,537	2,065
French Creek	Evergreen Forest	126	126
	Grasslands/Herbaceous	329	274
	Logging	2	2
	Shrubland	160	108
*French Creek Total		616	509
Gold Creek	Evergreen Forest	104	104
	Grasslands/Herbaceous	378	315
	Shrubland	172	116
*Gold Creek Total		654	535
Grose Creek	Grasslands/Herbaceous	114	95
	Shrubland	9	6
	Small Grains	1	0
Grose Creek Total		124	101
Headwaters Wise River	Bare Rock/Sand/Clay	4	4
	Evergreen Forest	310	310
	Grasslands/Herbaceous	295	246
	Shrubland	516	348
*Headwaters Wise River Total		1,126	908

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Jerry Creek	Evergreen Forest	457	457
	Grasslands/Herbaceous	764	637
	Logging	1	1
	Pasture/Hay	1	1
	Shrubland	466	314
	Woody Wetlands	1	1
*Jerry Creek Total		1,692	1,412
Lacy Creek	Evergreen Forest	152	152
	Grasslands/Herbaceous	32	26
	Logging	1	1
	Shrubland	113	76
*Lacy Creek Total		297	255
LaMarche Creek	Bare Rock/Sand/Clay	5	5
	Evergreen Forest	685	685
	Grasslands/Herbaceous	2,196	1,830
	Logging	3	3
	Pasture/Hay	2	1
	Shrubland	1,085	731
	Small Grains	3	0
*LaMarche Creek Total		3,979	3,256
Lost Creek	Evergreen Forest	46	46
	Grasslands/Herbaceous	414	345
	Shrubland	154	104
	Small Grains	1	0
Lost Creek Total		615	495
Lower Divide Creek	Evergreen Forest	37	37
	Grasslands/Herbaceous	557	464
	Pasture/Hay	1	1
	Shrubland	133	89
	Small Grains	3	0
Lower Divide Creek Total		730	591
Lower Pattengail Creek	Bare Rock/Sand/Clay	1	1
	Evergreen Forest	214	214
	Grasslands/Herbaceous	130	108
	Shrubland	327	221
*Lower Pattengail Creek Total		672	543

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Lower Willow Creek	Evergreen Forest	33	33
	Grasslands/Herbaceous	823	686
	Pasture/Hay	10	7
	Shrubland	649	437
	Small Grains	33	2
	Woody Wetlands	1	1
Lower Willow Creek Total		1,549	1,166
Lower Wise River	Evergreen Forest	217	217
	Grasslands/Herbaceous	301	251
	Logging	3	3
	Pasture/Hay	4	3
	Shrubland	204	137
*Lower Wise River Total		729	611
McCartney Creek	Evergreen Forest	4	4
	Grasslands/Herbaceous	622	518
	Pasture/Hay	2	2
	Shrubland	237	160
	Small Grains	4	0
McCartney Creek Total		869	684
Mclean Creek	Evergreen Forest	7	7
	Grasslands/Herbaceous	79	65
	Shrubland	49	33
Mclean Creek Total		134	105
Middle Pattengail Creek	Evergreen Forest	182	182
	Grasslands/Herbaceous	66	55
	Shrubland	58	39
*Middle Pattengail Creek Total		306	277
Middle Wise River	Evergreen Forest	421	421
	Grasslands/Herbaceous	548	456
	Shrubland	645	435
	Woody Wetlands	2	2
*Middle Wise River Total		1,615	1,314

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Moose Creek	Evergreen Forest	127	127
	Grasslands/Herbaceous	631	526
	Logging	6	6
	Mixed Forest	5	5
	Pasture/Hay	1	1
	Shrubland	474	319
	Woody Wetlands	2	2
Moose Creek Total		1,246	986
Mudd Creek	Evergreen Forest	66	66
	Grasslands/Herbaceous	69	57
	Logging	6	6
	Pasture/Hay	8	5
	Shrubland	44	30
	Small Grains	1	0
*Mudd Creek Total		194	164
Nez Perce Creek	Grasslands/Herbaceous	407	339
	Shrubland	100	68
Nez Perce Creek Total		507	406
North Fork Divide Creek	Evergreen Forest	152	152
	Grasslands/Herbaceous	233	194
	Logging	4	4
	Shrubland	104	70
North Fork Divide Creek Total		493	420
Oregon Creek	Grasslands/Herbaceous	102	85
	Shrubland	26	18
*Oregon Creek Total		128	103
Rochester Creek	Evergreen Forest	4	4
	Grasslands/Herbaceous	859	716
	Shrubland	345	233
Rochester Creek Total		1,209	953
Rock Creek	Evergreen Forest	255	255
	Grasslands/Herbaceous	819	682
	Pasture/Hay	6	4
	Shrubland	578	390
	Small Grains	31	2
Rock Creek Total		1,688	1,333

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Sassman Gulch	Evergreen Forest	12	12
	Grasslands/Herbaceous	149	124
	Shrubland	105	71
Sassman Gulch Total		266	207
Sawlog Creek	Evergreen Forest	73	73
	Grasslands/Herbaceous	149	124
	Shrubland	40	27
*Sawlog Creek Total		262	224
Seven Springs Creek	Grasslands/Herbaceous	106	88
	Shrubland	113	76
Seven Springs Creek Total		219	165
Sevenmile Creek	Evergreen Forest	14	14
	Grasslands/Herbaceous	240	200
	Shrubland	81	55
*Sevenmile Creek Total		335	269
Seymour Creek	Bare Rock/Sand/Clay	2	2
	Evergreen Forest	186	186
	Grasslands/Herbaceous	1,133	944
	Logging	6	6
	Shrubland	574	387
	Woody Wetlands	1	1
*Seymour Creek Total		1,902	1,526
Sixmile Creek	Evergreen Forest	3	3
	Grasslands/Herbaceous	309	257
	Shrubland	69	47
*Sixmile Creek Total		381	307
Soap Gulch	Evergreen Forest	12	12
	Grasslands/Herbaceous	578	482
	Shrubland	231	156
Soap Gulch Total		822	650
Squaw Creek	Evergreen Forest	182	182
	Grasslands/Herbaceous	129	108
	Shrubland	52	35
*Squaw Creek Total		363	324

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Trapper Creek	Evergreen Forest	219	219
	Grasslands/Herbaceous	1,499	1,249
	Pasture/Hay	2	2
	Shrubland	871	587
	Small Grains	12	1
Trapper Creek Total		2,604	2,058
Twelvemile Creek	Evergreen Forest	54	54
	Grasslands/Herbaceous	543	452
	Logging	2	2
	Shrubland	155	104
*Twelvemile Creek Total		754	613
Upper Birch Creek[1]	Bare Rock/Sand/Clay	2	2
	Evergreen Forest	278	278
	Grasslands Herbaceous	409	340
	Shrubland	572	385
Upper Birch Creek Total[1]		1,261	1,005
Upper Divide Creek	Evergreen Forest	89	89
	Grasslands/Herbaceous	726	605
	Logging	6	6
	Shrubland	197	133
	Woody Wetlands	1	1
Upper Divide Creek Total		1,019	834
Upper Pattengail Creek	Evergreen Forest	242	242
	Grasslands/Herbaceous	91	75
	Shrubland	119	80
*Upper Pattengail Creek Total		452	398
Upper Willow Creek	Bare Rock/Sand/Clay	2	2
	Evergreen Forest	170	170
	Grasslands/Herbaceous	607	506
	Logging	2	2
	Shrubland	380	256
Upper Willow Creek Total		1,161	936
Upper Wise River	Evergreen Forest	259	259
	Grasslands/Herbaceous	295	245
	Logging	1	1
	Shrubland	439	296
*Upper Wise River Total		993	801

Table C-6. Existing and potential sediment loads from upland erosion by land cover type for each 6th code HUC (Sub-Watershed) and for the Middle and Lower Big Hole watershed (i.e. all HUCs). HUCS within the middle Big Hole watershed are denoted with an asterisk.

Subwatershed	Land Cover Classification	Existing Sediment (tons/yr)	Potential Sediment (tons/yr)
Wickiup Creek	Evergreen Forest	30	30
	Grasslands/Herbaceous	183	152
	Logging	1	1
	Shrubland	68	46
Wickiup Creek Total		281	228
Wyman Creek	Evergreen Forest	165	165
	Grasslands/Herbaceous	50	42
	Logging	1	1
	Shrubland	87	59
*Wyman Creek Total		303	266
Middle and Lower Big Hole Watershed	**Bare Rock**	**20**	**20**
	Deciduous Forest	**1**	**1**
	Evergreen Forest	**8,600**	**8,600**
	Mixed Forest	**5**	**5**
	Grasslands/Herbaceous	**36,430**	**30,359**
	Logging	**110**	**110**
	Pasture/Hay	**258**	**168**
	Shrubland	**19,505**	**13,144**
	Small Grains	**318**	**20**
	Woody Wetlands	**12**	**12**
Middle and Lower Big Hole Total		**65,260**	**52,439**

[1]The loads for the Upper Birch Creek watershed were derived outside of the model based on the land cover acreage in the upper watershed compared to the entire Birch Creek watershed.

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