APPENDIX G - ROCK CREEK TPA ROAD SEDIMENT ASSESSMENT & MODELING

Appendix G is based report prepared for the DEQ by ATKINS, July 2012.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

G1.0 INTRODUCTION

An assessment of the road network within the Rock TMDL Planning Area (TPA) was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. This assessment employed GIS, field data collection, and sediment modeling to assess sediment inputs from the unpaved road network. In addition, sediment inputs from failed culverts were also evaluated, along with an evaluation of fish passage at assessed crossings.

G1.1 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 G1-1**). Additional supporting information was also collected in the Antelope Creek watershed, Upper Willow Creek watershed, and the West Fork Rock Creek watershed.

Table G1-1. Waterbody Segments Addressed during the Road 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)

G2.0 METHODS

Methods employed in this assessment are outlined in *Quality Assurance Project Plan and Sampling and Analysis Plan: Assessment of Unpaved Roads for TMDL Development (Task Order 18: Task 2b)* (U.S. Environmental Protection Agency, 2011) and *Road Sediment Assessment and Modeling: Rock TMDL Planning Area Road GIS Layers and Summary Statistics* (Atkins Water Resource Group, 2011) and summarized below.

G2.1 SEDIMENT INPUTS FROM UNPAVED ROADS

Sediment inputs from unpaved roads were evaluated through a combination of GIS analysis, field data collection and computer modeling.

G2.1.1 GIS Analysis

Prior to field data collection, GIS data layers representing land ownership, road network, stream network, watersheds, and ecoregions were used to identify road crossings throughout the Rock TPA. Land ownership was divided into four categories: U.S. Forest Service, U.S. Bureau of Land Management, Montana State Trust Lands, and Private. The roads layer was primarily derived from the Travel Routes for Region 1 geodatabase developed by the U.S. Forest Service and available from the Northern Region Geospatial Library (http://www.fs.fed.us/r1/gis/), supplemented with the State of Montana Base Map Service Center Transportation Framework Theme data. Stream layers were developed using the National Hydrography Dataset (NHD) 1:24,000 high-resolution flowline layer. Flowlines were limited to streams/rivers and artificial paths; ditches and pipelines were not included. Watersheds were delineated on the basis of the USGS 6th Hydrologic Unit Code (HUC12) layer and modified where necessary to delineate the subwatersheds of interest. Landscapes were delineated according to the EPA 2002 level IV ecoregions (Woods et al., 2002). These GIS layers were utilized to develop a database of stream crossings and parallel road segments that includes land ownership, road surface type, subwatershed, and ecoregion attributes in one attribute table.

Through GIS analysis, 339 road crossings were identified within the Rock TPA, 207 of which were identified as unpaved road crossings (gravel or native material) based on attribute information contained in the roads database (**Table G2-1**). During this initial GIS analysis, 125 crossings were identified with an 'unknown' surface type. Following the initial GIS analysis, road surface types were assigned to the 125 crossings with an 'unknown' surface type based on an assessment of proximal road segments located within the vicinity of each crossing lacking road surface type information. Additional GIS analysis of proximal road segments indicates 122 of these crossings are likely unpaved, resulting in an estimated total of 329 unpaved road crossings in the Rock TPA (**Table G2-1**).

Table G2-1. Road Surface Types in the Rock TPA

Road Surface Type	Number of Crossings based on GIS Attribute Information	Number of Crossings Re-classified based on Attributes of Proximal Road Segments	Total Number of Crossings
Paved	7	3	10
Gravel	42	4	46
Native	165	118	283
Unknown	125		
Total Crossings	**339**	**125**	**339**
Total Unpaved Crossings	**207**	**122**	**329**

Through GIS analysis, 411.58 miles of road were identified within the Rock TPA, with only 5.63 miles (1.4%) identified as paved roads. Parallel road segments located within 150 feet of streams were also identified using GIS, totaling 57.24 miles (13.9%), 32.24 miles of which were identified as unpaved road segments within 150 feet of a stream channel. An additional 23.53 miles were classified as 'unknown' based on attribute information in the roads database, the majority of which are likely unpaved.

G2.1.2 Field Data Collection

A field assessment of unpaved roads was conducted by performing an inspection of road crossings and parallel road segments throughout the Rock TPA in October 2011. For each unpaved crossing, a series of measurements were performed to characterize road design, maintenance level, condition, culvert size, and sediment loading potential. Field measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any Best Management Practices (BMPs).

G2.1.2.1 Crossing Assessment Sites

A total of 45 unpaved road crossings were randomly selected prior to field data collection. Out of the 45 pre-selected sites, 34 sites were visited in the field in October of 2011 and field forms were completed at 23 sites. Notes regarding road condition were recorded at the remaining 11 pre-selected sites, including if the road was closed preventing access to the site, though no actual data was collected. An additional 7 alternate sites were also visited and field forms were completed, for a total of 41 field assessed sites. Out of the 41 field assessed sites, field forms were completed at a total of 30 sites, while five out of the 41 assessed sites were not observed on-the-ground due to closed roads. Of the remaining six field assessed sites, one site was on a paved road, four sites had no defined stream channel, and one site lacked a crossing due to errors in the GIS stream and road layers which indicated a crossing where there is only a parallel road segment. Out of the 30 sites for which field forms were completed, three were on roads that were closed, but not re-vegetated or obliterated.

During field data collection, an additional examination of the road network in the South Fork Antelope Creek was conducted since no roads were identified in the GIS data layers. Based on color aerial imagery from 2011 and on-the-ground reconnaissance, two unpaved road crossings were identified in the South Fork Antelope Creek watershed, both of which were assessed in the field. Thus, a total of 441 unpaved road crossings were identified in the Rock TPA, 41 of which were assessed in the field, with field data collection completed at 30 sites. The 30 sites where field data collection was completed were analyzed using the Water Erosion Prediction Project (WEPP) soil erosion model, while the remaining 11 field assessed sites were used to refine the road database developed through GIS analysis (**Figure G2-1**).

G2.1.2.2 Parallel Road Segment Assessment Sites

A total of 32.24 miles of unpaved parallel road segments within 150 feet of streams were identified in the Rock TPA, while an additional 23.53 miles were classified as ‘unknown’, the majority of which are likely unpaved as well. During field data collection, sediment inputs to stream channels from parallel road segments were not observed. Thus, no field data was collected along parallel road segments in the Rock TPA.

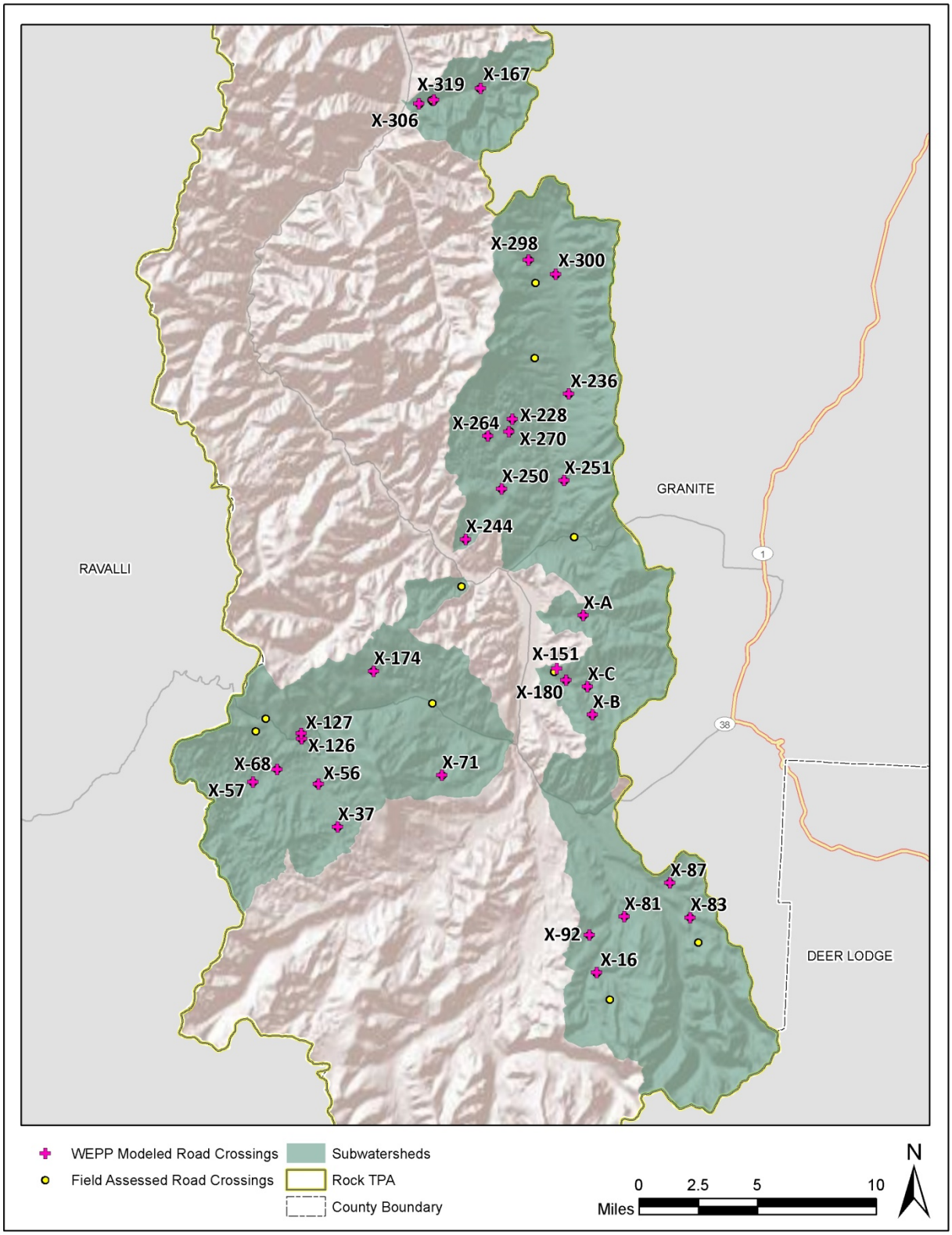

Figure G2-1. Field Assessed Road Crossings and WEPP Modeled Road Crossings in the Rock TPA

G2.1.3 WEPP Modeling

Sediment loading from unpaved road crossings was estimated using the WEPP:Road soil erosion model version 2011.12.20 (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model developed by the U.S. Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The WEPP:Road model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Field data collected from each field assessed site provided the following input data necessary to run the WEPP:Road model:

- Road design: insloped, bare ditch; insloped, vegetated or rocked ditch; outsloped, rutted; outsloped unrutted
- Road surface: native, graveled, paved
- Traffic level: high, low, none
- Soil texture: clay loam, silt loam, sandy loam, loam
- Rock content
- Gradient, length and width of the road, fill and buffer
- Climate data
- Years to simulate

The WEPP:Road model was used to evaluate existing conditions at each road crossing based on the field collected data. The WEPP:Road model was also used to estimate the potential to reduce sediment loads through the application of Best Management Practices (BMPs). During field data collection, the location of potential BMPs, such as water bars and rolling dips, were identified and the distance to the stream crossing was measured. During the BMP modeling scenario, the contributing road length was reduced from the existing length to the potential BMP length based on the field measured values.

G2.1.4 Potential Culvert Failures

A coarse assessment for each culvert was preformed on-site in order to measure and identify characteristics of the culvert, including measurements of structure type, structure diameter, structure gradient, bankfull width upstream of the culvert, fill height, fill length, fill width, outlet invert, and the presence of streambed materials in the culvert. This information was then used to estimate potential sediment loads from a culvert failure. At each culvert assessed in the field, flood frequencies for the 2, 5, 10, 25, 50, and 100-year events were determined based on the bankfull width upstream of the culvert using U.S. Geological Survey Southwest Montana Region regression equations (Parrett and Johnson, 1998). The Urban Drainage and Flood Control District Sewer and Culvert Hydraulics Version 2.0 (http://www.udfcd.org/) spreadsheet model was then utilized to establish the flow capacity of each field assessed culvert. The amount of sediment contributed during a culvert failure was calculated based on the volume of road fill overlaying the culvert with the assumption that culvert failure would erode sediment to a width equal to the bankfull width of the stream channel upstream of the culvert. For this analysis, an estimated soil weight of 1.66 tons/yard^3 was utilized based on the maximum unit weight for dry well-graded subangular sand presented in Table 1:4 of *Introductory Soil Mechanics and Foundations: Geotechnical Engineering Forth Edition (Sowers, 1979)*.

G2.2 FISH PASSAGE ANALYSIS

At each field assessed unpaved road crossing site, an evaluation of the culvert was performed, including measurements of structure type, structure diameter, structure gradient, bankfull width upstream of the

culvert, outlet invert, and the presence of streambed materials in the culvert. These measurements were used to determine if the culvert represented a fish passage barrier at various flow conditions based on the U.S. Forest Service Region 10 Fish Passage Evaluation Criteria as described in *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska (U.S. Department of Agriculture, Forest Service, Alaska Region, 2002)*.

G3.0 RESULTS

The results of this assessment examining sediment loading from roads to streams within the Rock TPA are presented in the following sections. The road and stream network developed through GIS data analysis is presented in **Figure G3-1**, while field assessed sites are presented by landownership in **Figure G3-2** and by level IV ecoregion in **Figure G3-3**. Sediment modeling and extrapolation was based on PRISM precipitation zones (**Figure G3-4**) and calculated by subwatershed for each of the 6th code subwatersheds (**Figure G3-5**) within the Rock TPA.

G3.1 SEDIMENT INPUTS FROM UNPAVED ROADS

Sediment inputs from unpaved road crossings were evaluated using the WEPP:Road model. The potential to reduce sediment loads from unpaved roads through the application of Best Management Practices (BMPs) were also evaluated using the WEPP:Road model. During field data collection, potential locations for the application of BMPs, including water bars and rolling dips, were identified and the distance to the stream crossing was measured. For the BMP scenario, this distance was applied in the WEPP:Road model to estimate the potential to decrease sediment contributions through the application of BMPs. In addition, sediment inputs from potential culvert failures were also evaluated.

G3.1.1 WEPP Model Input Parameters

Road condition data collected throughout the Rock TPA in October 2011 was input directly into the WEPP:Road model following guidance outlined in *WEPP Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery Technical Documentation*, which is available on the Internet at http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html. In addition to field collected data, the WEPP:Road model requires the selection of site-specific climate data to provide an estimate of mean annual precipitation. The WEPP Climate Generator was used to create a climate station based on weather data from the Philipsburg Ranger Station climate station maintained by the U.S. Forest Service (Western Regional Climate Center Cooperative Station ID# 246472) with a period of record from 1955 to the present. Precipitation in the Rock TPA ranges from 16-18” to 38-42” annually based on data collected from 1971 to 2000 and compiled by the PRISM Group at Oregon State University (http://nris.mt.gov/nsdi/nris/precip71_00.html). Road crossing assessments in the Rock TPA were conducted at sites located in precipitation zones ranging from 16-18” to 30-34”. For the Rock TPA, stream crossings were grouped into three precipitation zones for the purposes of sediment load modeling and extrapolation: <20”, 20-26”, and >26”. The mean precipitation value of 14.6” at the Philipsburg Montana climate station was adjusted by 20%, 60%, and 90% to approximate the mean values within the <20”, 20-26”, and >26” precipitation zones, respectively, as presented in **Table G3-1** and **Figure G3-4**. Mean annual sediment loads from unpaved road crossings were estimated using field collected data and site-specific precipitation data in the WEPP:Road model.

Table G3-1. Precipitation Data Applied in the WEPP:Road Model

Climate Station	Mean Precipitation (Inches)	Percent Adjustment	Adjusted Mean Precipitation (Inches)	PRISM Precipitation Zone (Inches)
Phillipsburg, MT	14.6	20%	17.5	<20
Phillipsburg, MT	14.6	60%	23.2	20-26
Phillipsburg, MT	14.6	90%	27.9	>26

G3.1.2 Unpaved Road Crossings

Out of 441 unpaved road crossings delineated in GIS and during on-the-ground reconnaissance, 41 were assessed in the field and field data was collected at 30 sites (**Figure G3-6**). From these 30 crossings, the estimated mean annual sediment load is 0.012 tons, with a mean annual sediment load of 0.004 tons contributed from each assessed unpaved road crossing (**Attachment G1**). For extrapolation to the subwatershed scale, unpaved road crossings were grouped based on precipitation zone as presented in **Table G3-2** and **Attachment G2**.

Table G3-2. Unpaved Road Crossing Mean Annual Sediment Loads for Precipitation Zones

PRISM Precipitation Zone (inches)	Number of sites Assessed	Mean Annual Load (Tons)	Mean Annual Load with BMP's (Tons)
<20	5	0.0029	0.0027
20-26	17	0.0181	0.0052
>26	8	0.0047	0.0025

The number of crossings identified in GIS was corrected for assumed errors in the GIS database by reducing the total number of GIS identified crossings based on the difference in the number of field assessed sites and the number of sites which were positively identified as unpaved road crossings of streams. During the field assessment, 30 of the 41 GIS-identified crossings (73%) were found to be unpaved road crossings of streams. Thus, it was assumed that the GIS data analysis over-estimated the number of crossings by 27%. Based on this assumption, the total number crossings identified in GIS in each sub-watershed was reduced by 27%, with the exception of South Fork Antelope Creek, where the two crossings identified through aerial imagery as discussed in **Section G2.1.2.1** were both verified during field data collection. Both the GIS identified number of crossings and the corrected number of crossings are presented in **Table G3-3** for each subwatershed, along with mean annual sediment load for the existing conditions and the mean annual sediment load achievable through the application of BMPs. For assessed stream segments within the Rock TPA, the estimated existing mean annual sediment load from unpaved road crossings is 2.636 tons (**Table G3-3**). Through the application of BMPs, it is estimated that this load can be reduced to 0.959 tons. A complete evaluation of sediment loads at the subwatershed scale is presented in **Attachment G3**.

Table G3-3. Unpaved Road Crossing Mean Annual Sediment Loads by Subwatershed

Subwatershed	Number of Crossings Identifed in GIS	Corrected Number of Crossings based on Field Data	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
West Fork Rock Creek Headwaters	12	9	0.042	0.022	47%
Upper West Fork Rock Creek	25	18	0.087	0.046	47%
Middle West Fork Rock Creek	18	13	0.062	0.033	47%
Lower West Fork Rock Creek	59	43	0.597	0.194	67%
West Fork Rock Creek Total	**114**	**83**	**0.787**	**0.296**	**62%**
East Fork Reservoir	0	0	0.000	0.000	0%
Meadow Creek	30	22	0.241	0.083	66%
East Fork Rock Creek	30	22	0.299	0.098	67%
East Fork Rock Creek Total	**60**	**44**	**0.541**	**0.181**	**66%**
Upper Willow Creek Headwaters	15	11	0.101	0.038	63%
Upper Upper Willow Creek	30	22	0.354	0.107	70%
Middle Upper Willow Creek	16	12	0.035	0.032	7%
Lower Upper Willow Creek	27	20	0.125	0.065	48%
Miners Gulch	20	15	0.199	0.066	67%
Scotchman Gulch	2	1	0.015	0.006	62%
Upper Willow Creek Total	**110**	**80**	**0.828**	**0.313**	**62%**
Antelope Creek (Rock Mallard)	12	9	0.070	0.031	56%
South Fork Antelope Creek	2	2	0.021	0.008	62%
Antelope Creek Total	**14**	**11**	**0.091**	**0.039**	**57%**
Quartz Gulch	1	1	0.013	0.004	71%
Basin Gulch	1	1	0.002	0.002	7%
Eureka Gulch	2	1	0.004	0.004	7%
Eureka Gulch Total	**4**	**3**	**0.020**	**0.010**	**50%**
Brewster Creek Total	**29**	**21**	**0.236**	**0.081**	**66%**
Flat Gulch Total	**4**	**3**	**0.053**	**0.015**	**71%**
Sluice Gulch Total	**6**	**4**	**0.080**	**0.023**	**71%**
Rock TPA Total	**341**	**250**	**2.636**	**0.959**	**64%**

G3.1.3 Unpaved Parallel Road Segments

A total of 32.24 miles of unpaved parallel road segments within 150 feet of streams were identified in the Rock TPA, while an additional 23.53 miles were classified as 'unknown', the majority of which are likely unpaved as well (**Figure G3-7**). During field data collection, sediment inputs to stream channels from parallel road segments were not observed. Thus, no field data was collected along parallel road segments in the Rock TPA and no sediment load analysis was performed.

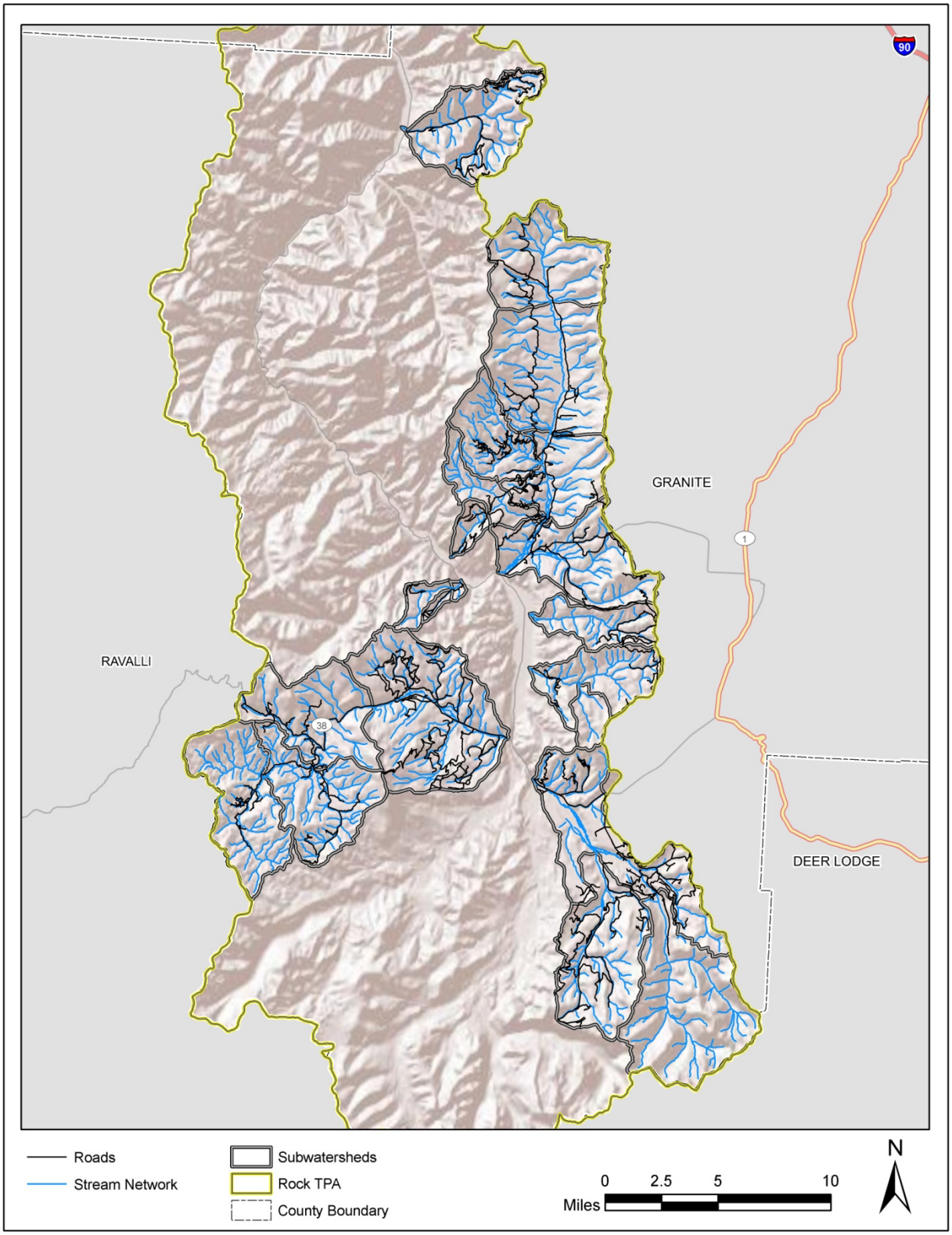

Figure G3-1. Road and Stream Networks in the Rock TPA

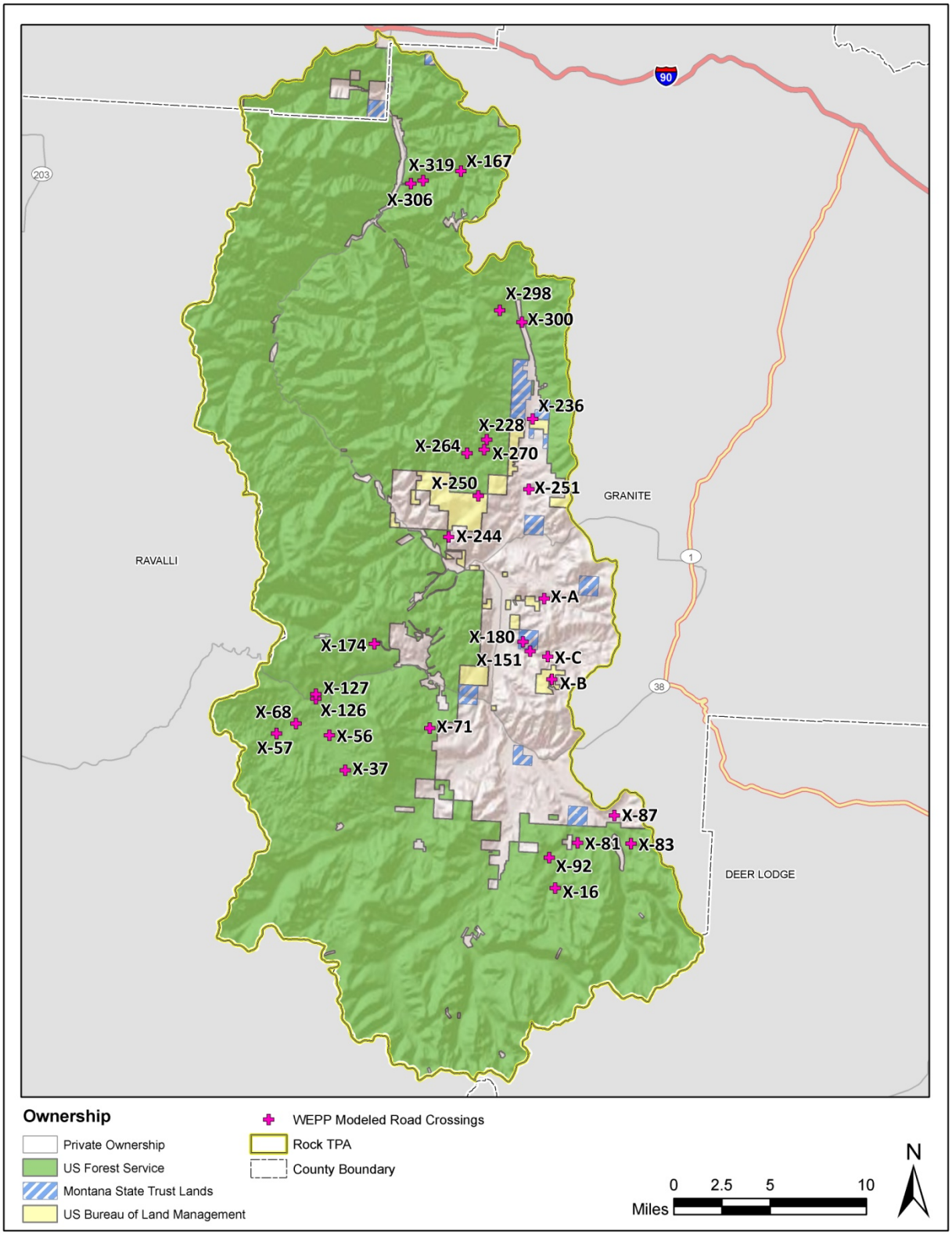

Figure G3-2. Landownership in the Rock TPA

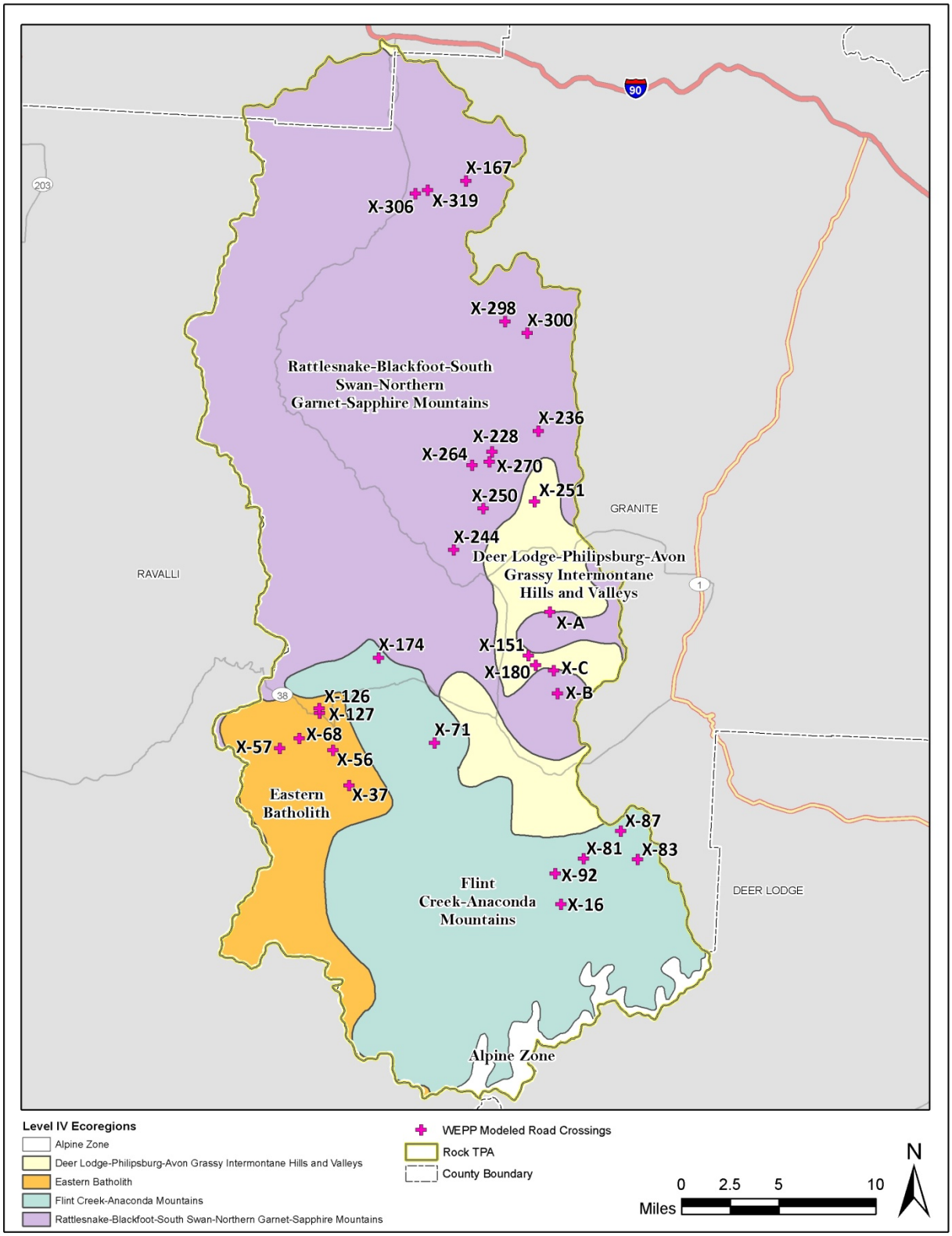

Figure G3-3. Level IV Ecoregions in the Rock TPA

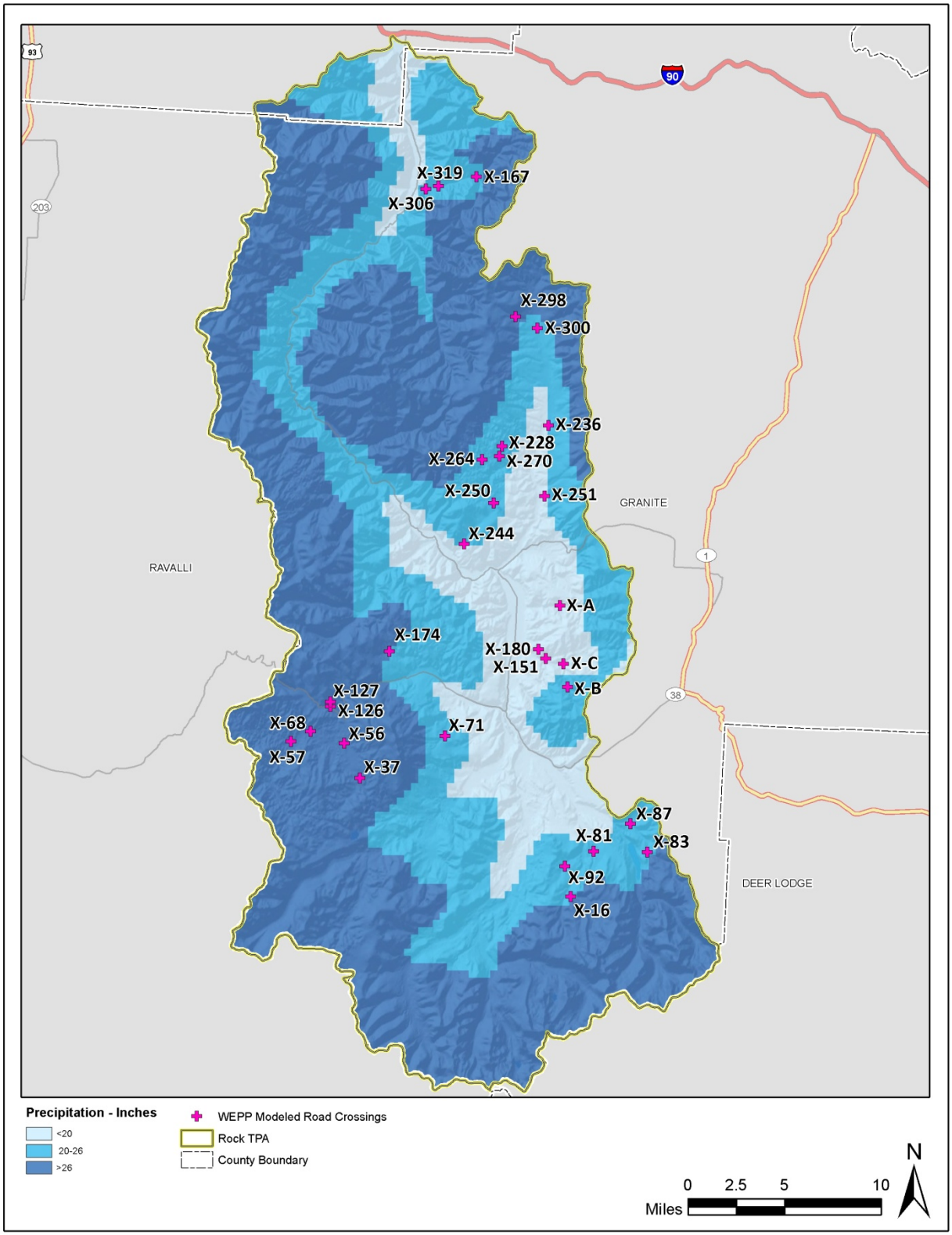

Figure G3-4. Precipitation Patterns in the Rock TPA

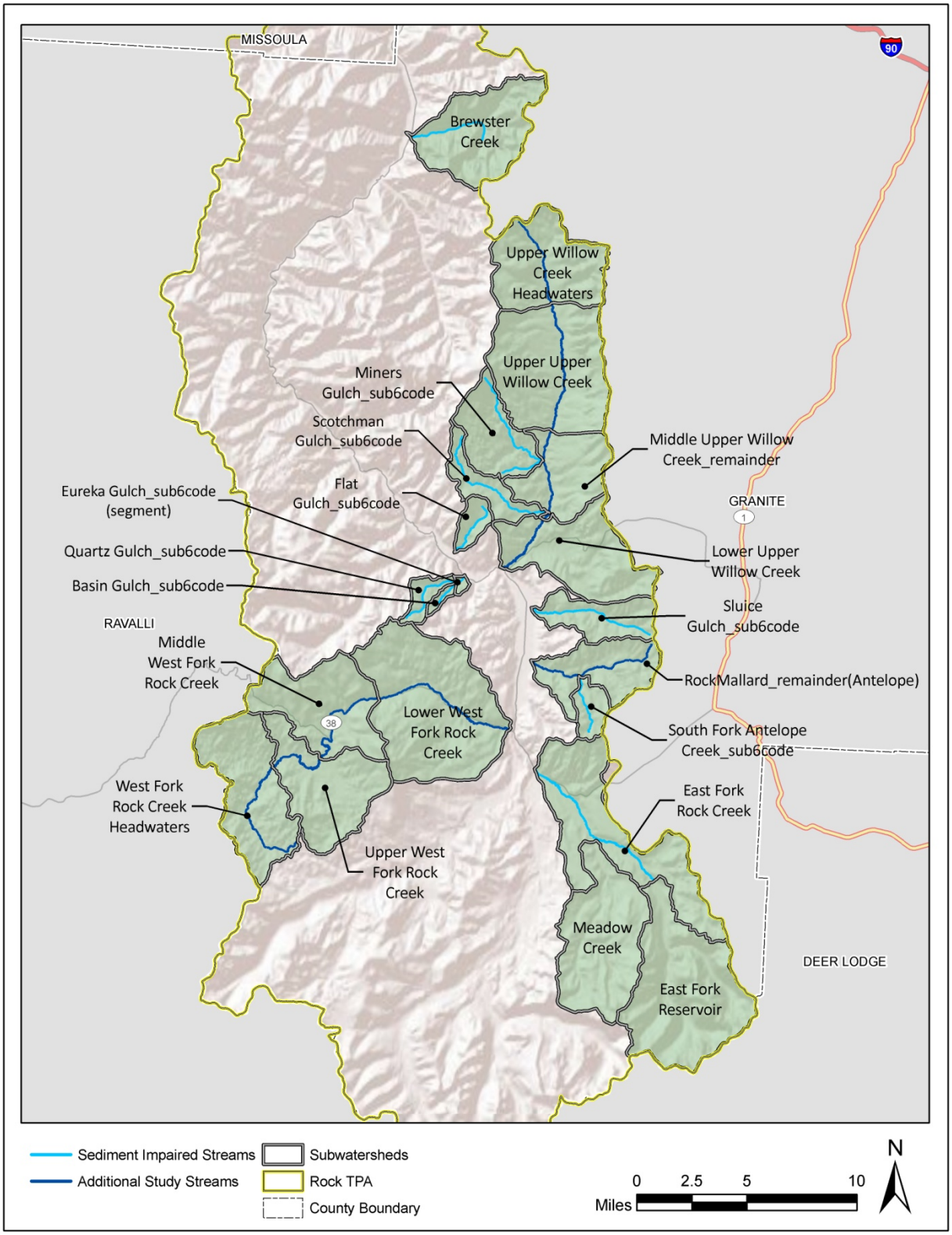

Figure G3-5. Subwatersheds in the Rock TPA

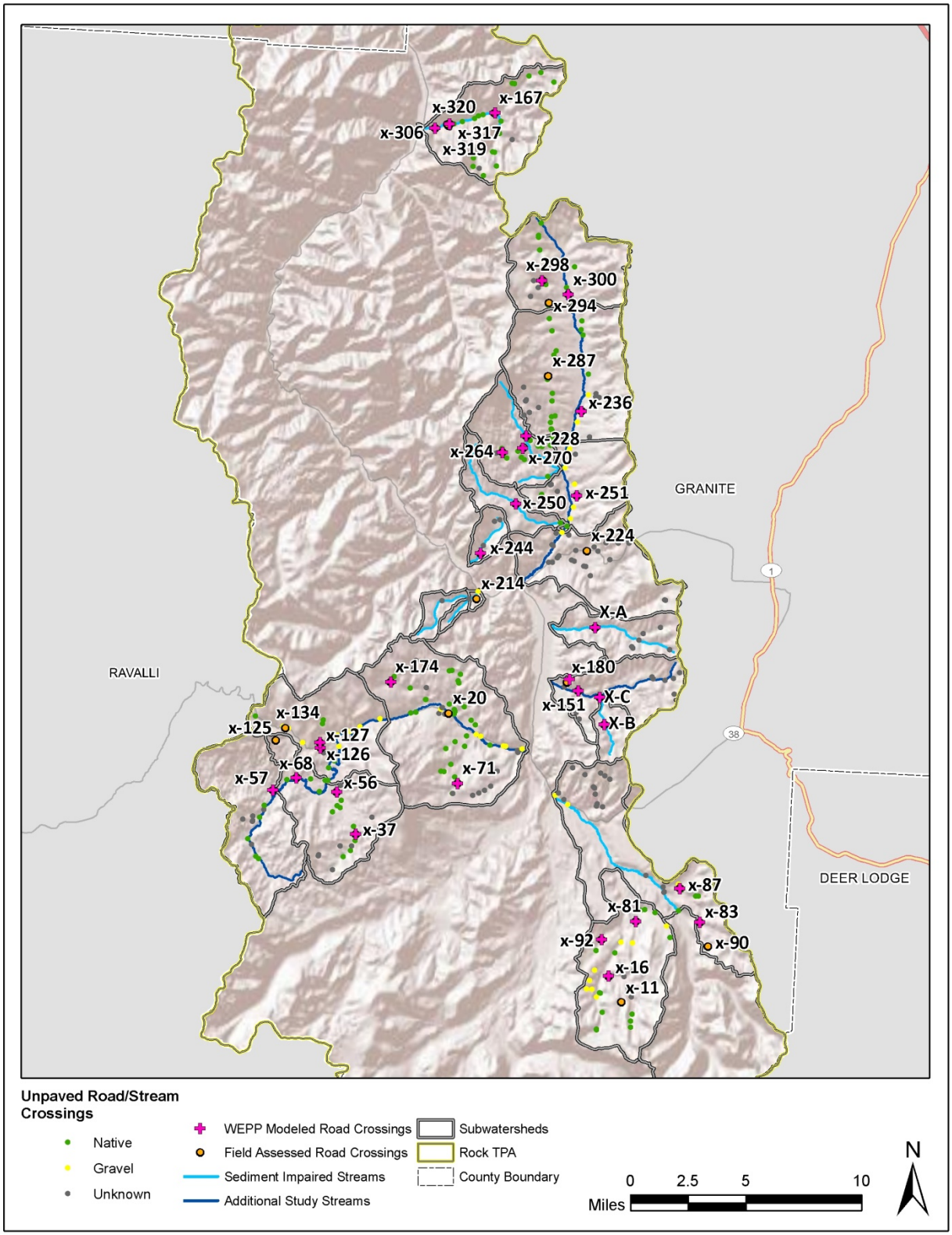

Figure G3-6. Unpaved Road Crossings in the Rock TPA

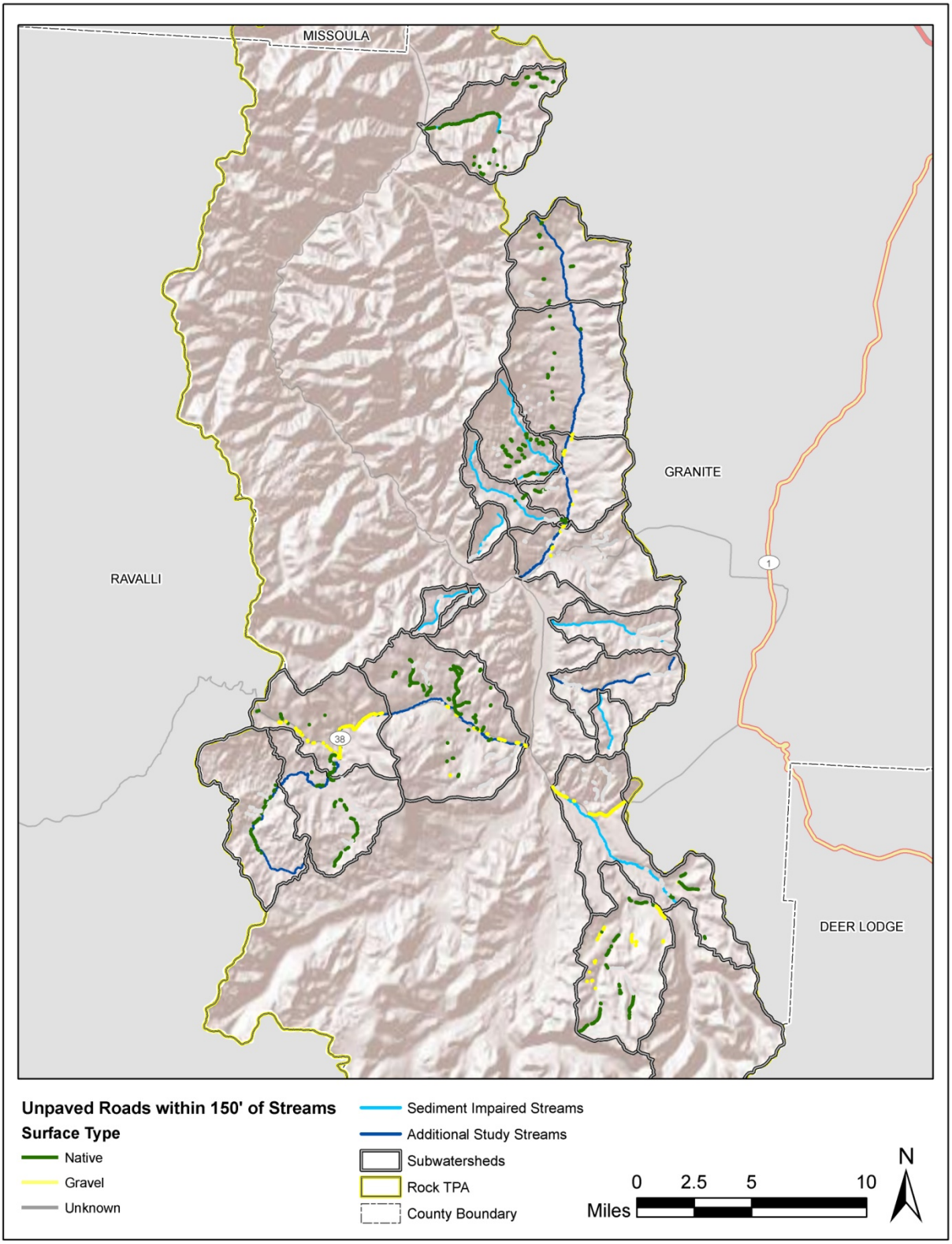

Figure G3-7. Unpaved Parallel Road Segments in the Rock TPA

G3.1.4 Potential Culvert Failures

Within the Rock TPA, 23 out of 27 culverts assessed in the field (85%) are capable of passing the two-year flood event, while only 9 of these culverts (33%) pass a 100-year flood event (**Tables G3-4** and **G3-5**, **Attachment G4**). Once a culvert's carrying capacity is exceeded, the potential for culvert failure increases, though the point at which a given culvert will fail remains uncertain. Hydraulic analysis of a culvert is extremely complex and potential sediment loads from the eroding fill as presented in **Table G3-4** are estimates assuming the entire height and length of road fill are eroded to a width equal to the bankfull width of the stream.

Table G3-4. Culvert Failure and Potential Sediment Load Evaluation

Location ID	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Culvert Capacity (cfs)	Potential Sediment Load if Culvert Fails (Tons)
X-174	7	14	19	28	36	43	112	48
X-126	7	14	19	28	36	43	26	68
X-127	4	9	13	19	24	30	13	24
X-68	17	32	45	63	79	94	51	59
X-37	13	25	35	50	63	76	12	48
X-71	39	69	92	126	156	185	149	122
X-251	4	9	13	19	24	30	100	52
X-236	6	11	16	23	30	36	9	33
X-B	4	9	13	19	24	30	124	148
X-C	60	104	138	184	227	268	27	111
X-151	32	59	79	108	135	160	16	24
X-180	6	11	16	23	30	36	49	125
X-87	45	80	107	144	179	211	177	80
X-83	10	19	27	38	48	59	53	394
X-81	32	59	79	108	135	160	61	159
X-16	10	19	27	38	48	59	179	74
X-92	7	14	19	28	36	43	51	55
X-250	4	9	13	19	24	30	95	52
X-228	10	19	27	38	48	59	146	133
X-270	2	4	6	8	11	14	11	6
X-264	3	7	10	15	19	24	6	6
X-300	7	14	19	28	36	43	40	10
X-298	7	14	19	28	36	43	115	512
X-244	17	32	45	63	79	94	8	11
X-167	10	19	27	38	48	59	54	33
X-319	32	59	79	108	135	160	107	43
X-306	7	14	19	28	36	43	9	7

Grey cells indicate culvert fails to pass a given discharge

Table G3-5. Culvert Failure Summary

Flood Frequency	Number of Culverts Passing	Number of Culverts Failing	Percent Passing	Percent Failing
Q2	23	4	85%	15%
Q5	20	7	74%	26%
Q10	18	9	67%	33%
Q25	15	12	56%	44%
Q50	12	15	44%	56%
Q100	9	18	33%	67%

If a culvert fails for a given event, the replacement culvert should address several issues. First, culverts typically cause changes in the upstream elevation and the new culvert should mitigate these effects to ensure that culvert placement does not negatively affect the surrounding habitat. Next, environmental considerations such as fish passage need to be accurately predicted. New three-sided culverts, where the bottom of the culvert is typically the natural channel bottom, allow better holding habitat and maintain a continuous stream channel bottom. The hydrology of the area should also be determined and directly related to the culvert design size for the given watershed. Following these principals will help improve the stream system, increase fish habitat, and reduce potential sediment loads from failed culverts.

G3.2 Fish Passage Analysis

Out of 30 road crossings evaluated in the field, 27 had culverts, each of which was assessed as a potential fish passage barrier based on the U.S. Forest Service Region 10 Fish Passage Evaluation Criteria. This analysis uses site-specific information to evaluate fish passage at culverts, which are classified as "green", "red", or "grey" (**Table G3-6**). Culvert slope, the culvert span-to-bedwidth ratio, and the outlet perch are evaluated as potential limiting factors affecting fish passage. In the Rock TPA, none of the culverts allowed fish passage, while 26 culverts (96%) were classified as fish passage barriers (**Attachment G5**). In general, too steep of slope led to these culverts being classified as fish passage barriers.

Table G3-6. Fish Passage Evaluation

Fish Passage Evaluation Categories	Fish Passage Evaluation Criteria	Number of Culverts	Percentage of Total Culverts Assessed
Green[1]	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows	0	0%
Red[2]	conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows	26	96%
Grey[3]	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability	1	4%

G4.0 Discussion

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. Mean annual sediment contributions from unpaved roads at stream crossings for these nine stream segments range

from 0.013 tons in Quartz Gulch to 0.541 tons in the East Fork Rock Creek (**Table G4-1**). Through the application of Best Management Practices, existing sediment loads from unpaved road crossings could be reduced by 50% to 71%.

Table G4-1. Unpaved Road Crossing Mean Annual Sediment Loads for Sediment Impaired Stream Segments

Subwatershed	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
East Fork Rock Creek Total	0.541	0.181	66%
Miners Gulch	0.199	0.066	67%
Scotchman Gulch	0.015	0.006	62%
South Fork Antelope Creek	0.021	0.008	62%
Quartz Gulch	0.013	0.004	71%
Eureka Gulch Total	0.020	0.010	50%
Brewster Creek Total	0.236	0.081	66%
Flat Gulch Total	0.053	0.015	71%
Sluice Gulch Total	0.080	0.023	71%

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ATTACHMENT G1 - UNPAVED ROAD CROSSING FIELD DATA AND WEPP MODELED SEDIMENT LOAD

Waterbody	Location ID	Date	Latitude	Longitude	Level 4 Ecoregion	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
													L	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R		
unnamed	X-174	10/10/11	46.26431	-113.65053	FCAM	>26	Sand L	10	Insloped Veg/rock ditch	Native	Low	30	3.0	325	14	0.3	1	7	30	6.66	3.5	270	14	0.3	1	55	10	3.96	10.6	3.3
unnamed	X-126	10/10/11	46.22073	-113.71071	EB	>26	Sand L	10	Outsloped Unrutted	Part. Grav.	High	30	1.5	30	23	70	6	0.3	1	8.39	0.5	25	23	70	6	0.3	1	8.23	16.6	16.6
unnamed	X-127	10/10/11	46.22410	-113.71119	EB	>26	Sand L	30	Outsloped Unrutted	Gravel	Low	30	8.0	475	14	38	4	18	13	15.27	2.0	32	14	38	4	18	1	2.02	17.3	5.7
unnamed	X-68	10/10/11	46.20123	-113.73086	EB	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	1.0	47	13	30	7	0.3	1	1.20	1.2	1.2
Bowles Creek	X-57	10/10/11	46.19284	-113.75145	EB	>26	Sand L	30	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	3.0	160	14	0.3	1	0.3	1	0.09	0.1	0.0
Sod Basin Creek	X-56	10/10/11	46.19366	-113.69390	EB	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	0.5	20	12	0.3	1	0.3	1	0.03	0.5	12	12	0.3	1	0.3	1	0.02	0.1	0.1
unnamed	X-37	10/10/11	46.16811	-113.67477	EB	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	1.0	103	13	42	9	0.3	1	2.69	0.5	5	13	42	9	0.3	1	2.68	5.4	5.4
unnamed	X-71	10/10/11	46.20314	-113.58571	FCAM	20-26	Sand L	40	Outsloped Unrutted	Gravel	Low	30	1.0	35	12	40	7	0.3	1	0.78	0.5	17	12	40	7	0.3	1	0.34	1.1	1.1
unnamed	X-251	10/10/11	46.38665	-113.49159	DLPAGIHV	<20	Sand L	30	Outsloped Unrutted	Gravel	Low	50	3.0	172	23	55	10	0.3	1	13.87	7.0	250	23	0.3	1	10	72	0.00	13.9	13.9
unnamed	X-236	10/10/11	46.43948	-113.49134	RBSSNGSM	20-26	Sand L	20	Outsloped Unrutted	Gravel	Low	30	2.0	170	18	50	7	0.3	1	7.87	6.0	315	18	50	7	0.3	1	23.01	30.9	23.6
Sluice Gulch	X-A	10/11/11	46.30498	-113.46892	DLPAGIHV	<20	Sand L	0	Outsloped Unrutted	Native	Low	50	-	-	-	-	-	-	-	0.00	4.0	104	7	0.3	1	0.3	1	0.05	0.1	0.1
South Fork Antelope Creek	X-B	10/11/11	46.24460	-113.45621	RBSSNGSM	20-26	Sand L	20	Outsloped Unrutted	Native	Low	30	9.0	195	-	48	30	0.3	1	16.13	6.0	195	15	48	30	0.3	1	10.39	26.5	10.3
South Fork Antelope Creek	X-C	10/11/11	46.26152	-113.46180	RBSSNGSM	<20	Sand L	5	Outsloped Unrutted	Native	Low	50	4.0	104	12	50	1	0.3	1	3.90	11.0	240	12	0.3	1	14	15	0.00	3.9	1.7
Antelope Creek	X-151	10/11/11	46.26487	-113.48116	DLPAGIHV	<20	Sand L	20	Outsloped Unrutted	Native	Low	50	-	-	-	-	-	-	-	0.00	0.5	11	10	40	6	0.3	1	0.23	0.2	0.2
unnamed	X-180	10/11/11	46.27171	-113.48958	DLPAGIHV	<20	Sand L	30	Insloped Veg/rock ditch	Native	Low	50	2.0	113	10	45	15	0.3	1	4.31	4.0	103	10	75	21	0.3	1	7.12	11.4	11.4
East Fork trib	X-87	10/11/11	46.14455	-113.38101	FCAM	20-26	Sand L	40	Outsloped Unrutted	Gravel	Low	30	6.0	825	14	40	7	0.3	1	35.98	-	-	-	-	-	-	-	0.00	36.0	4.8
LF trib	X-83	10/11/11	46.12396	-113.36141	FCAM	20-26	Sand L	40	Outsloped Unrutted	Gravel	Low	30	-	-	-	-	-	-	-	0.00	4.0	700	42	70	42	0.3	1	211.20	211.2	44.1
Meadow Creek trib	X-81	10/11/11	46.12259	-113.41927	FCAM	20-26	Sand L	20	Outsloped Unrutted	Native	Low	30	1.0	60	15	47	10	0.3	1	1.96	2.0	40	15	47	10	0.3	1	1.35	3.3	3.3
Brewster Creek	X-16	10/11/11	46.08766	-113.44123	FCAM	20-26	Sand L	40	Outsloped Unrutted	Native	Low	30	6.0	800	16	65	15	0.3	1	69.78	-	-	-	-	-	-	-	0.00	69.8	27.5
unnamed	X-92	10/11/11	46.11030	-113.44905	FCAM	20-26	Sand L	10	Outsloped Rutted	Native	Low	30	7.0	629	13	45	8	0.3	1	107.48	5.0	350	13	45	8	0.3	1	30.21	137.7	27.6
Scotchman Gulch	X-250	10/11/11	46.37957	-113.54624	RBSSNGSM	20-26	Sand L	30	Outsloped Unrutted	Native	Low	30	7.0	402	4	50	10	0.3	1	3.75	8.0	679	4	50	10	0.3	1	6.94	10.7	1.8
Miners Gulch	X-228	10/12/11	46.42228	-113.54019	RBSSNGSM	20-26	Sand L	10	Outsloped Unrutted	Native	Low	30	1.0	39	20	62	27	0.3	1	2.49	0.5	42	20	62	27	0.3	1	2.66	5.2	5.2
Trib to Miners	X-270	10/12/11	46.41455	-113.54243	RBSSNGSM	20-26	Sand L	5	Outsloped Unrutted	Native	Low	30	0.5	6	10	42	6	0.3	1	0.09	0.5	5	10	42	6	0.3	1	0.08	0.2	0.2
unnamed	X-264	10/12/11	46.41131	-113.56084	RBSSNGSM	20-26	Sand L	5	Insloped Bare	Native	Low	30	7.0	330	12	120	2.5	0.3	1	55.05	-	-	-	-	-	0.3	1	0.00	55.1	13.5
Corduroy Creek	X-300	10/12/11	46.51202	-113.50842	RBSSNGSM	20-26	Sand L	30	Outsloped Unrutted	Native	Low	30	0.5	4	10	35	5	0.3	1	0.07	0.5	5	10	35	5	0.3	1	0.08	0.2	0.2
unnamed	X-298	10/12/11	46.51984	-113.53307	RBSSNGSM	>26	Sand L	40	Outsloped Unrutted	Native	Low	30	3.0	80	14	60	22	0.3	1	3.57	7.0	278	14	60	22	0.3	1	20.94	24.5	8.1
Flat Gulch	X-244	10/12/11	46.34762	-113.57588	RBSSNGSM	20-26	Sand L	30	Outsloped Unrutted	Native	Low	30	6.0	49	9	46	5	0.3	1	1.37	9.0	152	9	46	5	0.3	1	6.47	7.8	2.6
Brewster Creek	X-167	10/12/11	46.62303	-113.58331	RBSSNGSM	20-26	Sand L	30	Outsloped Unrutted	Native	Low	30	8.0	240	11	65	6	0.3	1	13.41	1.0	155	11	65	6	0.3	1	3.74	17.2	10.5
Brewster Creek	X-319	10/12/11	46.61457	-113.62405	RBSSNGSM	20-26	Sand L	30	Outsloped Unrutted	Native	Low	30	4.0	210	12	60	6	5	7	3.29	-	-	-	-	-	-	-	0.00	3.3	1.3
Fourth of July Creek	X-306	10/12/11	46.61165	-113.63725	RBSSNGSM	20-26	Sand L	20	Outsloped Unrutted	Native	Low	30	0.5	13	11	45	3.5	0.3	1	0.25	0.5	18	11	45	3.5	0.3	1	0.35	0.6	0.6

Waterbody	Location ID	Segment 1 Installed BMPs		Segment 1 Potential BMPs		Road Crossing and BMP Notes/Comments
		L	R	L	R	
unnamed	X-174	none	none	water bar at 170'	water bar at 135'	RR contributes to d/s end, RL contributes to u/s end, vegetated fill on d/s side
unnamed	X-126	none	none	none	none	road outsloped, recently bladed
unnamed	X-127	rolling dip at 475'	none	rolling dip at 115'	none	well gravel road as BMP for steep slope
unnamed	X-68	-	none	-	none	gravel added to road, road sloping from right to left
Bowles Creek	X-57	-	none	-	water bar at 75'	road closed - administrative use only; sediment from road onto wooden bridge and into channel
Sod Basin Creek	X-56	none	none	none	none	relatively flat road, contribution from bridge deck, not fill slope
unnamed	X-37	none	-	none	none	relatively flat road, contribution from bridge deck, not fill slope
unnamed	X-71	none	none	slash filter	slash filter	dramatically outsloped with recent gravel
unnamed	X-251	-	none	veg to buffer	none	add veg to buffer as BMP on RL
unnamed	X-236	none	none	water bar at 75'	water bar at 85'	
Sluice Gulch	X-A	-	vegetated road bed	-	none	grassy road, no contribution on RL, small bare area on RL
South Fork Antelope Creek	X-B	rolling dip at 195'	rolling dip at 195'	rolling dip at 60'	rolling dip at 100'	streambed aggraded u/s end of culvert 1.5'
South Fork Antelope Creek	X-C	none	none	rolling dip at 45'	rolling dip at 39'	RR delivery u/s of culvert, RL too | vegetated road bed | 2 roads convey from RR
Antelope Creek	X-151	-	none	-	none	small distance from RR, none from RL, no buffer | not a source
unnamed	X-180	-	-	none	none	inputs at u/s end of culvert on R
East Fork trib	X-87	none	-	water bars at 340' and 110'	-	well maintained road, long contributing length, but relatively hardened road
LF trib	X-83	-	none	-	sediment basin at 146'	wide road at sharp curve with headcut on fillslope
Meadow Creek trib	X-81	none	none	none	none	no BMPs since outsloped
Brewster Creek	X-16	cross drain at 800'	-	rolling dip at 315'	-	RL flows past culvert, then contributes on d/s side
unnamed	X-92	none	none	192 bar	146 water bar	rolling dips on road on way to crossing
Scotchman Gulch	X-250	none	none	water bar at 90'	water bar at 90'	vegetated median 50 2x2 | at the ditch relief culvert ditch relief culverts on both sides along cutslope
Miners Gulch	X-228	none	none	none	none	relatively flat slope, pine trees growing on fill
Trib to Miners	X-270	none	none	none	none	little used road with main route
unnamed	X-264	none	-	rolling dip at 130'	-	-
Corduroy Creek	X-300	none	none	none	none	-
unnamed	X-298	none	none	none	rolling dip at 60'	closed road "Admin" hardened gravel surface limits erosion
Flat Gulch	X-244	none	none	none	rolling dip at 29'	ranch access road
Brewster Creek	X-167	none	none	rolling dip at 120'	none	-
Brewster Creek	X-319	berms on side of road	-	water bar at 80'	-	well maintained
Fourth of July Creek	X-306	none	none	none	none	reportedly dusty in summer graded once in spring

ATTACHMENT G2 - UNPAVED ROAD CROSSING PRECIPITATION ANALYSIS

Location ID	PRISM Precipitation Zone (Inches)	Number of Sites Assessed	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Potential Reduction in Sediment Load with BMPs (Tons)	Percent Reduction in Sediment Load
X-251	<20		0.0069	0.0069	0.0000	0%
X-A	<20		0.0000	0.0000	0.0000	0%
X-C	<20		0.0020	0.0008	0.0011	57%
X-151	<20		0.0001	0.0001	0.0000	0%
X-180	<20		0.0057	0.0057	0.0000	0%
Mean	**<20**	**5**	**0.0029**	**0.0027**	**0.0002**	**7%**
X-71	20-26		0.0006	0.0006	0.0000	0%
X-236	20-26		0.0154	0.0118	0.0037	24%
X-B	20-26		0.0133	0.0051	0.0081	61%
X-87	20-26		0.0180	0.0024	0.0156	87%
X-83	20-26		0.1056	0.0220	0.0836	79%
X-81	20-26		0.0017	0.0017	0.0000	0%
X-16	20-26		0.0349	0.0137	0.0212	61%
X-92	20-26		0.0688	0.0138	0.0550	80%
X-250	20-26		0.0053	0.0009	0.0045	84%
X-228	20-26		0.0026	0.0026	0.0000	0%
X-270	20-26		0.0001	0.0001	0.0000	0%
X-264	20-26		0.0275	0.0068	0.0208	75%
X-300	20-26		0.0001	0.0001	0.0000	0%
X-244	20-26		0.0039	0.0013	0.0026	67%
X-167	20-26		0.0086	0.0052	0.0034	39%
X-319	20-26		0.0016	0.0006	0.0010	62%
X-306	20-26		0.0003	0.0003	0.0000	0%
Mean	**20-26**	**17**	**0.0181**	**0.0052**	**0.0129**	**71%**
X-174	>26		0.0053	0.0016	0.0037	69%
X-126	>26		0.0083	0.0083	0.0000	0%
X-127	>26		0.0086	0.0029	0.0058	67%
X-68	>26		0.0006	0.0006	0.0000	0%
X-57	>26		0.0000	0.0000	0.0000	56%
X-56	>26		0.0000	0.0000	0.0000	0%
X-37	>26		0.0027	0.0027	0.0000	0%
X-298	>26		0.0123	0.0040	0.0082	67%
Mean	**>26**	**8**	**0.0047**	**0.0025**	**0.0022**	**47%**

ATTACHMENT G3 - UNPAVED ROAD CROSSING SUBWATERSHED SEDIMENT LOADS

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
West Fork Rock Creek Headwaters	USFS	>26	6	4	0.0047	0.0025	0.021	0.011	**47%**
			6[1]	4[1]			0.021[1]	0.011[1]	**47%[1]**
West Fork Rock Creek Headwaters	Private	>26	6	4	0.0047	0.0025	0.021	0.011	**47%**
			6[1]	4[1]			0.021[1]	0.011[1]	**47%[1]**
West Fork Rock Creek Headwaters			**12[2]**	**9[2]**			**0.042[2]**	**0.022[2]**	**47%[2]**
Upper West Fork Rock Creek	USFS	>26	18	13	0.0047	0.0025	0.062	0.033	**47%**
			18[1]	13[1]			0.062[1]	0.033[1]	**47%[1]**
Upper West Fork Rock Creek	Private	>26	7	5	0.0047	0.0025	0.024	0.013	**47%**
			7[1]	5[1]			0.024[1]	0.013[1]	**47%[1]**
Upper West Fork Rock Creek			**25[2]**	**18[2]**			**0.087[2]**	**0.046[2]**	**47%[2]**
Middle West Fork Rock Creek	USFS	>26	8	6	0.0047	0.0025	0.028	0.015	**47%**
			8[1]	6[1]			0.028[1]	0.015[1]	**47%[1]**
Middle West Fork Rock Creek	State	>26	9	7	0.0047	0.0025	0.031	0.017	**47%**
			9[1]	7[1]			0.031[1]	0.017[1]	**47%[1]**
Middle West Fork Rock Creek	Private	>26	1	1	0.0047	0.0025	0.003	0.002	**47%**
			1[1]	1[1]			0.003[1]	0.002[1]	**47%[1]**
Middle West Fork Rock Creek			**18[2]**	**13[2]**			**0.062[2]**	**0.033[2]**	**47%[2]**
Lower West Fork Rock Creek	USFS	<20	4	3	0.0029	0.0027	0.009	0.008	**7%**
Lower West Fork Rock Creek	USFS	20-26	16	12	0.0181	0.0052	0.212	0.061	**71%**
Lower West Fork Rock Creek	USFS	>26	2	1	0.0047	0.0025	0.007	0.004	**47%**
			22[1]	16[1]			0.228[1]	0.073[1]	**68%[1]**
Lower West Fork Rock Creek	State	<20	5	4	0.0029	0.0027	0.011	0.010	**7%**
Lower West Fork Rock Creek	State	20-26	2	1	0.0181	0.0052	0.027	0.008	**71%**
			7[1]	5[1]			0.037[1]	0.018[1]	**53%[1]**
Lower West Fork Rock Creek	Private	<20	6	4	0.0029	0.0027	0.013	0.012	**7%**
Lower West Fork Rock Creek	Private	20-26	24	18	0.0181	0.0052	0.318	0.092	**71%**
			30[1]	22[1]			0.331[1]	0.104[1]	**69%[1]**
Lower West Fork Rock Creek			**59[2]**	**43[2]**			**0.597[2]**	**0.194[2]**	**67%[2]**
West Fork Rock Creek Total			**114[3]**	**83[3]**			**0.787[3]**	**0.296[3]**	**62%[3]**
Meadow Creek	USFS	20-26	14	10	0.0181	0.0052	0.186	0.054	**71%**
Meadow Creek	USFS	>26	12	9	0.0047	0.0025	0.042	0.022	**47%**
			26[1]	19[1]			0.227[1]	0.076[1]	**67%[1]**
Meadow Creek	Private	>26	4	3	0.0047	0.0025	0.014	0.007	**47%**
			4[1]	3[1]			0.014[1]	0.007[1]	**47%[1]**
Meadow Creek			**30[2]**	**22[2]**			**0.241[2]**	**0.083[2]**	**66%[2]**
East Fork Rock Creek	USFS	20-26	1	1	0.0181	0.0052	0.013	0.004	**71%**
East Fork Rock Creek	USFS	>26	1	1	0.0047	0.0025	0.003	0.002	**47%**
			2[1]	1[1]			0.017[1]	0.006[1]	**66%[1]**
East Fork Rock Creek	State	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
			1[1]	1[1]			0.002[1]	0.002[1]	**7%[1]**
East Fork Rock Creek	County	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
East Fork Rock Creek	County	20-26	4	3	0.0181	0.0052	0.053	0.015	**71%**
			5[1]	4[1]			0.055[1]	0.017[1]	**69%[1]**
East Fork Rock Creek	Private	<20	6	4	0.0029	0.0027	0.013	0.012	**7%**
East Fork Rock Creek	Private	20-26	16	12	0.0181	0.0052	0.212	0.061	**71%**
			22[1]	16[1]			0.225[1]	0.073[1]	**67%[1]**
East Fork Rock Creek			**30[2]**	**22[2]**			**0.299[2]**	**0.098[2]**	**67%[2]**
East Fork Rock Creek Total			**60[3]**	**44[3]**			**0.541[3]**	**0.181[3]**	**66%[3]**
Upper Willow Creek Headwaters	USFS	20-26	5	4	0.0181	0.0052	0.066	0.019	**71%**
Upper Willow Creek Headwaters	USFS	>26	7	5	0.0047	0.0025	0.024	0.013	**47%**
			12[1]	9[1]			0.091[1]	0.032[1]	**65%[1]**
Upper Willow Creek Headwaters	Private	>26	3	2	0.0047	0.0025	0.010	0.006	**47%**

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
			3[1]	2[1]			0.010[1]	0.006[1]	**47%[1]**
Upper Willow Creek Headwaters			**15[2]**	**11[2]**			**0.101[2]**	**0.038[2]**	**63%[2]**
Upper Upper Willow Creek	USFS	<20	3	2	0.0029	0.0027	0.006	0.006	**7%**
Upper Upper Willow Creek	USFS	20-26	15	11	0.0181	0.0052	0.199	0.057	**71%**
			18[1]	13[1]			0.206[1]	0.063[1]	**69%[1]**
Upper Upper Willow Creek	County	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
Upper Upper Willow Creek	County	20-26	2	1	0.0181	0.0052	0.027	0.008	**71%**
			3[1]	2[1]			0.029[1]	0.010[1]	**66%[1]**
Upper Upper Willow Creek	Private	20-26	9	7	0.0181	0.0052	0.119	0.034	**71%**
			9[1]	7[1]			0.119[1]	0.034[1]	**71%[1]**
Upper Upper Willow Creek			**30[2]**	**22[2]**			**0.354[2]**	**0.107[2]**	**70%[2]**
Middle Upper Willow Creek	USFS	<20	3	2	0.0029	0.0027	0.006	0.006	**7%**
			3[1]	2[1]			0.006[1]	0.006[1]	**7%[1]**
Middle Upper Willow Creek	County	<20	9	7	0.0029	0.0027	0.019	0.018	**7%**
			9[1]	7[1]			0.019[1]	0.018[1]	**7%[1]**
Middle Upper Willow Creek	Private	<20	4	3	0.0029	0.0027	0.009	0.008	**7%**
			4[1]	3[1]			0.009[1]	0.008[1]	**7%[1]**
Middle Upper Willow Creek			**16[2]**	**12[2]**			**0.035[2]**	**0.032[2]**	**7%[2]**
Lower Upper Willow Creek	County	<20	5	4	0.0029	0.0027	0.011	0.010	**7%**
Lower Upper Willow Creek	County	20-26	2	1	0.0181	0.0052	0.027	0.008	**71%**
			7[1]	5[1]			0.037[1]	0.018[1]	**53%[1]**
Lower Upper Willow Creek	Private	<20	16	12	0.0029	0.0027	0.035	0.032	**7%**
Lower Upper Willow Creek	Private	20-26	4	3	0.0181	0.0052	0.053	0.015	**71%**
			20[1]	15[1]			0.088[1]	0.047[1]	**46%[1]**
Lower Upper Willow Creek			**27[2]**	**20[2]**			**0.125[2]**	**0.065[2]**	**48%[2]**
Miners Gulch	USFS	<20	6	4	0.0029	0.0027	0.013	0.012	**7%**
Miners Gulch	USFS	20-26	10	7	0.0181	0.0052	0.133	0.038	**71%**
			16[1]	12[1]			0.146[1]	0.050[1]	**65%[1]**
Miners Gulch	Private	20-26	4	3	0.0181	0.0052	0.053	0.015	**71%**
			4[1]	3[1]			0.053[1]	0.015[1]	**71%[1]**
Miners Gulch			**20[2]**	**15[2]**			**0.199[2]**	**0.066[2]**	**67%[2]**
Scotchman Gulch	County	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
Scotchman Gulch	County	20-26	1	1	0.0181	0.0052	0.013	0.004	**71%**
			2[1]	1[1]			0.015[1]	0.006[1]	**62%[1]**
Scotchman Gulch			**2[2]**	**1[2]**			**0.015[2]**	**0.006[2]**	**62%[2]**
Upper Willow Creek Total			**110[3]**	**80[3]**			**0.828[3]**	**0.313[3]**	**62%[3]**
Antelope Creek (Rock Mallard)	Private	<20	8	6	0.0029	0.0027	0.017	0.016	**7%**
Antelope Creek (Rock Mallard)	Private	20-26	4	3	0.0181	0.0052	0.053	0.015	**71%**
			12[1]	9[1]			0.070[1]	0.031[1]	**56%[1]**
Antelope Creek (Rock Mallard)			**12[2]**	**9[2]**			**0.070[2]**	**0.031[2]**	**56%[2]**
South Fork Antelope Creek	Private	<20	1	1	0.0029	0.0027	0.003	0.003	7%
South Fork Antelope Creek	Private	20-26	1	1	0.0181	0.0052	0.018	0.005	71%
			2[1]	2[1]			0.021[1]	0.008[1]	62%[1]
South Fork Antelope Creek			**2[2]**	**2[2]**			**0.021[2]**	**0.008[2]**	**62%[2]**
Antelope Creek Total			**14[3]**	**11[3]**			**0.091[3]**	**0.039[3]**	**57%[3]**
Quartz Gulch	Private	20-26	1	1	0.0181	0.0052	0.013	0.004	**71%**
			1[1]	1[1]			0.013[1]	0.004[1]	**71%[1]**
Quartz Gulch			**1[2]**	**1[2]**			**0.013[2]**	**0.004[2]**	**71%[2]**

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Basin Gulch	Private	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
			1[1]	1[1]			0.002[1]	0.002[1]	**7%[1]**
Basin Gulch			**1[2]**	**1[2]**			**0.002[2]**	**0.002[2]**	**7%[2]**
Eureka Gulch	County	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
			1[1]	1[1]			0.002[1]	0.002[1]	**7%[1]**
Eureka Gulch	Private	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
			1[1]	1[1]			0.002[1]	0.002[1]	**7%[1]**
Eureka Gulch			**2[2]**	**1[2]**			**0.004[2]**	**0.004[2]**	**7%[2]**
Eureka Gulch Total			**4[3]**	**3[3]**			**0.020[3]**	**0.010[3]**	**50%[3]**
Brewster Creek	USFS	20-26	11	8	0.0181	0.0052	0.146	0.042	**71%**
Brewster Creek	USFS	>26	12	9	0.0047	0.0025	0.042	0.022	**47%**
			23[1]	17[1]			0.188[1]	0.064[1]	**66%[1]**
Brewster Creek	County	<20	1	1	0.0029	0.0027	0.002	0.002	**7%**
			1[1]	1[1]			0.002[1]	0.002[1]	**7%[1]**
Brewster Creek	Private	20-26	3	2	0.0181	0.0052	0.040	0.011	**71%**
Brewster Creek	Private	>26	2	1	0.0047	0.0025	0.007	0.004	**47%**
			5[1]	4[1]			0.047[1]	0.015[1]	**68%[1]**
Brewster Creek Total			**29[2]**	**21[2]**			**0.236[2]**	**0.081[2]**	**66%[2]**
Flat Gulch	Private	20-26	4	3	0.0181	0.0052	0.053	0.015	**71%**
			4[1]	3[1]			0.053[1]	0.015[1]	**71%[1]**
Flat Gulch Total			**4[2]**	**3[2]**			**0.053[2]**	**0.015[2]**	**71%[2]**
Sluice Gulch	Private	20-26	6	4	0.0181	0.0052	0.080	0.023	**71%**
			6[1]	4[1]			0.080[1]	0.023[1]	**71%[1]**
Sluice Gulch Total			**6[2]**	**4[2]**			**0.080[2]**	**0.023[2]**	**71%[2]**
Rock TPA Total			**341**	**250**			**2.636**	**0.959**	**64%**

Meaning of colors in the table

[1]	**Subtotal for each subwatershed by land ownership**
[2]	**Total for all land ownerships**
[3]	**Total for all of the subwatersheds**

ATTACHMENT G4 - CULVERT FAILURE ANALYSIS

Location ID	Structure Type	Culvert Dimensions	Culvert Slope	Bankfull Width	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Capacity at Cross Section	Headwater Height (Fill Height)	Field Measured Fill Width	Modeled Fill Width*	Fill Length	Fill Volume*	Fill Volume*	Potential Sediment Load if Culvert Fails*
		(ft)	(%)	(ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft^3)	(CY)	(tons)
X-174	CMP	3	5	5	7	14	19	28	36	43	112	4.5	34	5	35	787.5	29	48
X-126	CMP	2	9	5	7	14	19	28	36	43	26	4	34	5	55	1100	41	68
X-127	CMP	1.5	16	4	4	9	13	19	24	30	13	3	31	4	32	384	14	24
X-68	Squash CMP	3.3 span 2.3 rise	2	8	17	32	45	63	79	94	51	4	14	8	30	960	36	59
X-37	CMP	1.5	1	7	13	25	35	50	63	76	12	4	30	7	28	784	29	48
X-71	Squash CMP	6 span 2.66 rise	6	12	39	69	92	126	156	185	149	5.5	30	12	30	1980	73	122
X-251	Cement Pipe	2.3	2	4	4	9	13	19	24	30	100	7	40	4	30	840	31	52
X-236	CMP	1.25	5	4.5	6	11	16	23	30	36	9	4	35	4.5	30	540	20	33
X-B	CMP	3	9	4	4	9	13	19	24	30	124	15	70	4	40	2400	89	148
X-C	CMP	2	2	15	60	104	138	184	227	268	27	5	25	15	24	1800	67	111
X-151	Smooth Pipe	1.66	5	11	32	59	79	108	135	160	16	3.5	17	11	10	385	14	24
X-180	CMP	2	8	4.5	6	11	16	23	30	36	49	15	60	4.5	30	2025	75	125
X-87	Squash CMP	4.58 span 2.91 rise	3	13	45	80	107	144	179	211	177	4	30	13	25	1300	48	80
X-83	Squash CMP	4 rise 3 span	5	6	10	19	27	38	48	59	53	2.91	154	6	367	6407.82	237	394
X-81	CMP	3	4	11	32	59	79	108	135	160	61	5	35	11	47	2585	96	159
X-16	CMP	4.5	5	6	10	19	27	38	48	59	179	8	42	6	25	1200	44	74
X-92	CMP	2.5	8	5	7	14	19	28	36	43	51	6	34	5	30	900	33	55
X-250	CMP	3.5	1.5	4	4	9	13	19	24	30	95	7	36	4	30	840	31	52
X-228	CMP	4	5	6	10	19	27	38	48	59	146	8	46	6	45	2160	80	133
X-270	CMP	1.5	8	2.5	2	4	6	8	11	14	11	2.5	24	2.5	15	93.75	3	6
X-264	CMP	1.5	2	3.5	3	7	10	15	19	24	6	1.5	22	3.5	19	99.75	4	6
X-300	Squash CMP	3.5 span 2.5 rise	0.5	5	7	14	19	28	36	43	40	3	21	5	11	165	6	10
X-298	CMP	3	5	5	7	14	19	28	36	43	115	16	81	5	104	8320	308	512
X-244	Squash CMP	1.5 span 1 rise	4	8	17	32	45	63	79	94	8	2	19	8	11	176	7	11
X-167	CMP	3	2.5	6	10	19	27	38	48	59	54	4.5	26	6	20	540	20	33
X-319	Squash CMP	6 span 4 rise	7	11	32	59	79	108	135	160	107	3.5	28	11	18	693	26	43
X-306	Squash CMP	1.5	4	5	7	14	19	28	36	43	9	2	21	5	12	120	4	7

*Assuming a fill width equal to the bankfull width

culvert fails to pass discharge

ATTACHMENT G5 - FISH PASSAGE ASSESSMENT

Location ID	Structure Type	Evaluation Method	Culvert Dimensions (ft)	Width (ft)	Culvert Slope (%)	Bankfull Width (ft)	Culvert/ Bankfull Ratio	Outlet Perch (inches)	Final Classification (# of failures)
X-174	CMP	3	3	3	5[2]	5	0.60[3]	0[1]	1[2]
X-126	CMP	3	2	2	9[2]	5	0.40[2]	6[2]	3[2]
X-127	CMP	3	1.5	1.5	16[2]	4	0.38[2]	0[1]	2[2]
X-68	Squash CMP	3	2.3	3.3	2[2]	8	0.41[2]	0[1]	2[2]
X-37	CMP	3	1.5	1.5	1[3]	7	0.21[2]	0[1]	1[2]
X-71	Squash CMP	3	2.66	6	6[2]	12	0.50[3]	0[1]	1[2]
X-251	Cement Pipe	3	2.3	2.3	2[2]	4	0.58[3]	0[1]	1[2]
X-236	CMP	3	1.25	1.25	5[2]	4.5	0.28[2]	0[1]	2[2]
X-B	CMP	3	3	3	9[2]	4	0.75[3]	8[2]	2[2]
X-C	CMP	3	2	2	2[2]	15	0.13[2]	1[3]	2[2]
X-151	Smooth Pipe	3	1.66	1.66	5[2]	11	0.15[2]	1[3]	2[2]
X-180	CMP	3	2	2	8[2]	4.5	0.44[2]	2.5[3]	2[2]
X-87	Squash CMP	3	2.91	4.58	3[2]	13	0.35[2]	0[1]	2[2]
X-83	Squash CMP	3	4	4	5[2]	6	0.67[3]	0[1]	1[2]
X-81	CMP	3	3	3	4[2]	11	0.27[2]	6[2]	3[2]
X-16	CMP	4	4.5	4.5	5[2]	6	0.75[3]	0[1]	1[2]
X-92	CMP	3	2.5	2.5	8[2]	5	0.50[3]	6[2]	2[2]
X-250	CMP	3	3.5	3.5	1.5[2]	4	0.88[1]	0[1]	1[2]
X-228	CMP	3	4	4	5[2]	6	0.67[3]	12[2]	2[2]
X-270	CMP	3	1.5	1.5	8[2]	2.5	0.60[3]	0[1]	1[2]
X-264	CMP	3	1.5	1.5	2[2]	3.5	0.43[2]	6[2]	3[2]
X-300	Squash CMP	3	2.5	3.5	0.5[3]	5	0.70[3]	0[1]	0[3]
X-298	CMP	3	3	3	5[2]	5	0.60[3]	0[1]	1[2]
X-244	Squash CMP	3	1	1.5	4[2]	8	0.19[2]	0[1]	2[2]
X-167	CMP	3	3	3	2.5[2]	6	0.50[3]	0[1]	1[2]
X-319	Squash CMP	3	4	6	7[2]	11	0.55[3]	0[1]	1[2]
X-306	Squash CMP	3	1.5	1.5	4[2]	5	0.30[2]	0[1]	2[2]

Note: Evaluation Method based on Table:1 Fish Passage Evaluation Criteria located in *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on the National Forests of Alaska*

1	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows	
2	conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows	
3	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability	