APPENDIX D- ROAD SEDIMENT ASSESSMENT, MADISON TMDL PLANNING AREA

TABLE OF CONTENTS

D1.0 INTRODUCTION

This appendix presents a sediment assessment of the unpaved road network within the Madison River TMDL Planning Area (TPA). Through a combination of GIS analysis, field assessment, and computer modeling, estimated sediment loads were developed for road crossing and parallel road segments in the impaired watersheds within the Madison TPA. Potential future conditions were also estimated after the application of sediment reducing Best Management Practices (BMPs).

D2.0 DATA COLLECTION

D2.1 SPATIAL ANALYSIS

Unpaved roads were identified in the impaired watersheds using a combination of aerial imagery and attribute information within the TIGER Roads Layer. Unpaved road crossings were identified as locations where the resulting unpaved roads layer intersected the National Hydrography Dataset (NHD) stream layer. Parallel road segments were identified by placing a 150-foot buffer around the NHD stream layer, and selecting sections of the unpaved roads layer that intersected this buffer. A total of 554 unpaved gravel road crossings and 130 miles of gravel unpaved parallel road segments were identified within the sediment-impaired watersheds of the Madison TPA.

D2.2 FIELD DATA COLLECTION

A total of 25 gravel unpaved crossings and 16 gravel parallel road segments totaling 4 miles were selected as representative and evaluated in the field in 2015 (**Tables D-1** & **D-2**). In cases where the original crossing or segment could not be sampled due to access issues or was found to be unpaved, a crossing or parallel road segment in the field with the closest spatial proximity was substituted, and identified with an "A" following the name. If a road crossed the stream twice at the same approximate location, then both segments of the crossing were sampled. The following information was collected at road crossings and parallel road segments: soil type, percent rock, road surface, road design, traffic level, and road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length).

Table D-1. Locations of sampled cross sections in the Madison TPA

Watershed	Cross-section	Latitude	Longitude
Red Canyon	X-1A	44.834	-111.201
Red Canyon	X-2A	44.836	-111.203
Watkins	X-2	44.836	-111.203
Red Canyon	X-3	44.831	-111.200
Watkins	X-4	44.799	-111.286
Watkins	X-5	44.806	-111.279
Red Canyon	X-13	45.060	-111.668
Bear	X-16A	45.168	-111.596
North Meadow	X-21	45.525	-111.835
North Meadow	X-25	45.514	-111.822
Bear	X-26A	45.162	-111.591

Table D-1. Locations of sampled cross sections in the Madison TPA

Watershed	Cross-section	Latitude	Longitude
South Meadow	X-26	45.471	-111.878
South Meadow	X-27A	45.468	-111.871
South Meadow	X-28A	45.449	-111.854
South Meadow	X-29	45.451	-111.854
North Meadow	X-33A	45.514	111.800
Wigwam	X-35 A	45.208	-111.761
North Meadow	X-38	45.233	-111.734
Blaine Spring	X-39A	45.210	-111.810
Blaine Spring	X-40	45.209	-111.802
Moore	X-46A	45.346	-111.730
Hot Springs	X-51A	45.565	-111.754
Hot Springs	X-52	45.587	-111.648
Hot Springs	X-53	45.573	-111.710
Red Canyon	X-RC extra	44.825	-111.197

Table D-2. Locations of sampled parallel road segments in the Madison TPA

Watershed	Road Name	Site ID	Upstream Latitude	Upstream Longitude	Downstream Latitude	Downstream Longitude
Red Canyon	USFS Rd 681	P-1A	44.824	-111.197	44.823	-111.197
Red Canyon	USFS Rd 681	P-2A	44.823	-111.197	44.821	-111.197
Red Canyon	USFS Rd 681	P-3A	44.834	-111.201		
Ruby		P-11	45.059	-111.712		
Ruby		P-12	45.060	111.715	45.060	-111.714
Ruby		P-13A	45.060	-111.716	45.060	-111.717
Bear	Bear Creek Rd E	P-16	45.163	-111.566	45.163	-111.569
Bear		P-17	45.156	-111.555	45.156	-111.555
South Meadow	Natl Forest Develop Road 1221 Rd	P-39A	45.450	-111.852	45.449	-111.849
Hot Springs	Bradley Creek Rd	P-40	45.53	-111.675	45.529	-111.675
North Meadow	N Meadow Creek Rd	P-41	45.474	-111.773	45.473	-111.773
North Meadow	N Meadow Creek Rd	P-42	45.469	111.773	45.468	111.773
North Meadow	N Meadow Creek Rd	P-48A	45.530	-111.849	45.529	-111.845
Hot Springs	Sterling Rd	P-49	45.573	-111.709	45.573	-111.708
Hot Springs	Bradley Creek Rd	P-55A			45.565	-111.653
Moore	Moore's Creek Rd	P-MC-extra			45.333	-111.748

D3.0 SEDIMENT LOADING EXTRAPOLATION

D3.1 SAMPLED CROSS-SECTION

The WEPP model (Flanagan and Livingston 1995) produced an estimate of sediment leaving the cross-section given the crossing characteristics and resulting contributing length. To estimate the sediment reduction at sampled cross sections if BMP's were implemented, the original field data was used in the WEPP model, but the length of road contributing sediment was shortened to 200 feet (**Table D-5**).

Table D-5. Estimated sediment leaving each sampled crossings, before and after BMPS

Watershed	XS ID	Contributing Length (ft)	Contributing Length-BMP's (ft)	Sediment Leaving Buffer (Tons/Yr)	Sediment Leaving Buffer After BMP's (Tons/Yr)
Red Canyon	X-1A	909	200	0.020	0.001
Red Canyon	X-2	22	200	0.004	0.004
Red Canyon	X-2A	243	200	0.011	0.005
Red Canyon	X-2A (2)	756	200	0.073	0.006
Red Canyon	X-3	78	200	0.025	0.025
Red Canyon	X-3	694	200	1.754	0.309
Watkins	X-4	853	200	0.059	0.007
South Meadow	X-5	11	200	0.001	0.001
Ruby	X-13	153	200	0.035	0.035
Bear	X-16A	350	200	0.611	0.349
North Meadow	X-21	77	200	0.000	0.000
North Meadow	X-25	260	200	0.332	0.226
North Meadow	X-25 (2)	226	200	0.270	0.226
South Meadow	X-26	507	200	0.074	0.014
South Meadow	X 26 (2)	109	200	0.016	0.016
Bear	x-26A	362	200	0.343	0.243
South Meadow	X-27A	235	200	0.077	0.064
South Meadow	X-28A	203	200	0.023	0.023
South Meadow	X-29	730	200	0.006	0.000
South Meadow	X-29 (2)	1000	200	0.013	0.000
North Meadow	X-33A	35	200	0.024	0.024
Wigwam	X-35 A	205	200	0.030	0.029
Wigwam	X-35 A (2)	277	200	0.108	0.070
North Meadow	X-38	35	200	0.006	0.006
Blaine	X-39A	93	200	0.007	0.007
Blaine	X-40	385	200	0.020	0.011
Moore	X-46A	678	200	0.012	0.004
Hot Springs	X-51A	635	200	0.013	0.004
Hot Springs	X-52	690	200	0.139	0.040
Hot Springs	X-53	188	200	0.028	0.028
Red Canyon	X-RC extra	449	200	0.497	0.151

D3.2 SAMPLED PARALLEL ROAD SEGMENTS

The WEPP model produced an estimate of sediment leaving the parallel road segment given the current length. To estimate the sediment reduction at sampled parallel road segments if BMP's were implemented, the original field data was used in the WEPP model, but the length of the parallel road segment contributing sediment was shortened to 500 feet (**Table D-6**).

Table D-6. Estimated sediment leaving each sampled parallel road segment, before and after BMPs

Watershed	PS ID	Road Length (ft)	Contributing Length-BMP's (ft)	Sediment Leaving Buffer (Tons/Yr)	Sediment Leaving Buffer After BMP's (Tons/Yr)
Bear	P-16	824	500	0.110	0.040
Bear	X 16A	350	500	0.611	0.611
Bear	P-17	381	500	0.015	0.015
Hot Springs	P-40	562	500	1.116	1.002
Hot Springs	P-49	179	500	0.097	0.097
Hot Springs	P-55A	1000	500	0.746	0.389
Moore	P-MC Extra	363	500	0.013	0.013
North Meadow	P-41	1000	500	1.111	0.622
North Meadow	P-42	160	500	0.020	0.020
North Meadow	P-48A	154	500	0.002	0.002
Red Canyon	P-1A	130	500	0.044	0.044
Red Canyon	P-1A (2)	443	500	0.203	0.203
Red Canyon	P-2A	914	500	0.062	0.034
Red Canyon	P-3A	883	500	0.802	0.443
Ruby	P-11	75	500	0.005	0.005
Ruby	P-11 (2)	119	500	0.008	0.008
Ruby	P-12	361	500	0.231	0.231
Ruby	P-13A	188	500	0.037	0.037
South Meadow	P-39 A	796	500	0.799	0.436

D3.3 WATERSHED LEVEL: CROSS-SECTIONS

For watersheds with > 20% of crossings sampled (Red Canyon, Watkins), the total sediment yield at crossings (sampled + unsampled) was determined by multiplying the total number of crossings estimated using GIS by the average yield per crossing at sampled cross-sections in that watershed (**Table D-7**). For the other watersheds, the sediment yield was estimated by weighing by ownership and elevation category according to the following method. First, the average sediment yield per crossing was determined for the following categories of crossings: Public, high elevation (>6300 feet); public, low elevation (≤ 6300 feet); private, low elevation (≤ 6300 feet) (**Table D-8**). Then the number of crossings in each category was multiplied by the average sediment yield for that type of crossings. For both methods, the private, high elevation crossings were excluded from the analysis due to low prevalence

and a lack of data. Results from all categories were summed to obtain a total estimate of sediment yield in the watershed from crossings. A similar method was used to determine yields once BMP's were implemented (**Table D-9**).

Table D-7. Summary of estimated sediment loads leaving sampled crossings, by watershed

Watershed	No. Gravel Crossings	No. Crossings Evaluated	Total Sediment at Crossings-Field (Tons/Year)	Average Sediment Per Crossing-Field (Tons/Year)	Total Sediment at Crossings - BMP Field (Tons/Year)	Average Sediment Per Crossing-BMP (Tons/Year)
Bear	84	2	0.80	0.40	0.29	0.15
Blaine	33	2	0.02	0.01	0.02	0.01
Hot Springs	96	3	0.15	0.05	0.06	0.02
Moore	30	1	0.01	0.01	0.00	0.00
North Meadow	87	3	0.52	0.17	0.40	0.13
Red Canyon	15	6	1.99	0.33	0.42	0.07
Ruby	9	1	0.03	0.03	0.03	0.03
South Meadow	39	5	0.18	0.04	0.10	0.02
Watkins	3	1	0.05	0.05	0.01	0.01
Wigwam	66	1	0.12	0.12	0.08	0.08
Antelope	7	0	NA	NA	NA	NA
Elk	19	0	NA	NA	NA	NA
Cherry	66	0	NA	NA	NA	NA

Table D-8. Summary of sediment loads leaving sampled crossings by ownership and elevation category

Ownership/Elevation Category	No. Crossings	Total Sediment by Category (Tons/Year)	Total Sediment By Category with BMP's (Tons/Year)	Average Sediment Per Crossing (Tons/Year)	Average Sediment Per Crossing-BMP's (Tons/Year)
Public, high elevation	8	2.18	0.50	0.272	0.063
Public, low elevation	5	0.19	0.09	0.038	0.017
Private, high elevation	0	NA	0.00	NA	NA
Private, low elevation	11	1.49	1.02	0.136	0.093

Table D-9. Estimated sediment loads from crossings in each subwatershed

Watershed	No. Gravel Crossings	No. Public, Low	No. Private, Low	No. Public, High	No. Private, High	Method Used	Total Sediment (Tons /Yr)	Total Sediment (Tons/Yr) with BMP's	% Reduct-ion
Antelope	7	0	0	6	1	own/elev	1.63	0.38	77
Bear	84	11	71	0	4	own/elev	10.06	6.76	33
Blaine	33	1	31	0	1	own/elev	4.25	2.89	32
Cherry	66	0	59	4	4	own/elev	9.10	5.71	37
Elk	19	2	17	0	0	own/elev	2.39	1.61	33
Hot Springs	96	43	54	1	0	own/elev	9.25	5.80	37
Moore	30	5	17	6	2	own/elev	4.13	2.04	51
North Meadow	87	3	64	20	1	own/elev	14.25	7.23	49
Red Canyon	15	0	0	13	2	watershed	4.30	0.90	79
Ruby	9	9	0	0	0	own/elev	0.34	0.15	55
South Meadow	39	3	18	18	1	own/elev	7.46	2.85	62
Watkins	3	0	0	3	0	watershed	0.15	0.02	88
Wigwam	66	13	37	7	10	own/elev	7.43	4.09	45

D3.4 WATERSHED LEVEL: PARALLEL ROAD SEGMENTS

The sediment yield at sampled parallel road segments was estimated by weighing by ownership and elevation category according to the following method. First, the average sediment yield (tons/mile/yr) was estimated for each ownership/elevation category based on sampled parallel road segments across the Madison TPA: Public, high elevation (>6300 feet); public, low elevation (≤ 6300 feet); private, low elevation (≤ 6300 feet) (**Table D-10**). To estimate the sediment yield per mile from parallel road segments for each watershed, the number of miles in each category was multiplied by the average sediment yield per mile in that category. Results from all categories were summed to obtain a total estimate of sediment yield from parallel road segments in the watershed (**Table D-11**).

Table D-10. Summary of sediment leaving the buffer at parallel road segments by ownership and elevation category, using results from the WEPP modeling approach

	No. Parallel Segments Sampled	Length of Parallel Road Segments Sampled-miles	Total Sediment By Category (Tons/Year)	Total Sediment By Category with BMP's (Tons/Year)	Average Sediment Per Mile (Tons/Year)	Average Sediment Per Mile with BMP's
Public, high elevation	3	1.33	1.111	0.723	0.835	0.544
Public, low elevation	8	1.05	2.959	2.124	2.818	2.023
Private, high elevation	0	0	NA	NA	NA	NA
Private, low elevation	5	1.45	1.352	0.792	0.932	0.546

Table D-11. Estimated sediment entering streams from parallel road segments by subwatershed

	Public Low (miles)	Private Low (miles)	Public High (miles)	Private High (miles)	Public Low (Tons)	Private Low (Tons)	Public High (Tons)	Private High (Tons)	Public Low (tons BMP)	Private Low (Tons BMP)	Public High (Tons BMP)	Private High (Tons BMP)	Total(Tons/Yr)	Total (Tons/Yr -BMP's)	% Reduction
Antelope	0.00	0.00	0.08	0.00	0.00	0.00	0.07	NA	0.00	0.00	0.04	NA	0.07	0.04	45.78
Bear	1.72	21.33	0.22	0.92	4.86	19.89	0.19	NA	2.90	9.71	0.10	NA	24.93	12.72	49.00
Blaine	0.20	7.79	0.00	0.04	0.55	7.26	0.00	NA	0.33	3.54	0.00	NA	7.81	3.87	50.40
Cherry	0.00	12.26	0.60	0.38	0.00	11.43	0.50	NA	0.00	5.58	0.27	NA	11.93	5.85	50.95
Elk	0.86	3.98	0.00	0.00	2.42	3.71	0.00	NA	1.45	1.81	0.00	NA	6.14	3.26	46.84
Hot Springs	9.28	11.81	1.32	0.00	26.16	11.01	1.10	NA	15.65	5.38	0.60	NA	38.27	21.62	43.51
Moore	2.16	6.72	2.01	0.86	6.07	6.27	1.68	NA	3.63	3.06	0.91	NA	14.02	7.60	45.77
North Meadow	1.46	13.56	3.14	0.00	4.13	12.65	2.62	NA	2.47	6.17	1.42	NA	19.39	10.06	48.11
Red Canyon	0.00	0.00	3.07	1.76	0.00	0.00	2.56	NA	0.00	0.00	1.39	NA	2.56	1.39	45.78
Ruby	4.36	0.71	0.92	0.00	12.27	0.66	0.77	NA	7.34	0.32	0.42	NA	13.70	8.08	41.03
South Meadow	1.10	4.92	2.78	0.11	3.11	4.58	2.33	NA	1.86	2.24	1.26	NA	10.02	5.36	46.51
Watkins	0.00	0.00	0.27	0.01	0.00	0.00	0.22	NA	0.00	0.00	0.12	NA	0.22	0.12	45.78
Wigwam	1.10	4.79	1.21	1.11	3.11	4.47	1.01	NA	1.86	2.18	0.55	NA	8.60	4.59	46.56

D4.0 REFERENCES

Flanagan, D. C. and S. J. Livingston. 1995. USDA-Water Erosion Prediction Project User Summary. NSERL Report No. 11, National Soil Erosion Research Lab, USDA, West Lafayette IN, 139 pp.