APPENDIX E - UPLAND SEDIMENT ASSESSMENT FOR ELK CREEK

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E1.0 AERIAL ASSESSMENT

DEQ conducted an analysis of upland sediment for the Elk Creek watershed, as numerous near stream agricultural fields were identified through on the ground and aerial photo observation to have a potentially significant sediment contribution to the stream (**Figures E-1 to E-5**). Many of the fields have areas within 50-100 feet of the stream that have poor cover and little to no riparian buffer to filter sediment contribution to the stream. Collectively, these areas of ground disturbance have the potential to be significant sediment sources if proper BMPs are not implemented and maintained.

Figure E-1. Fields along Elk Creek identified as having an elevated sediment contribution to the stream.

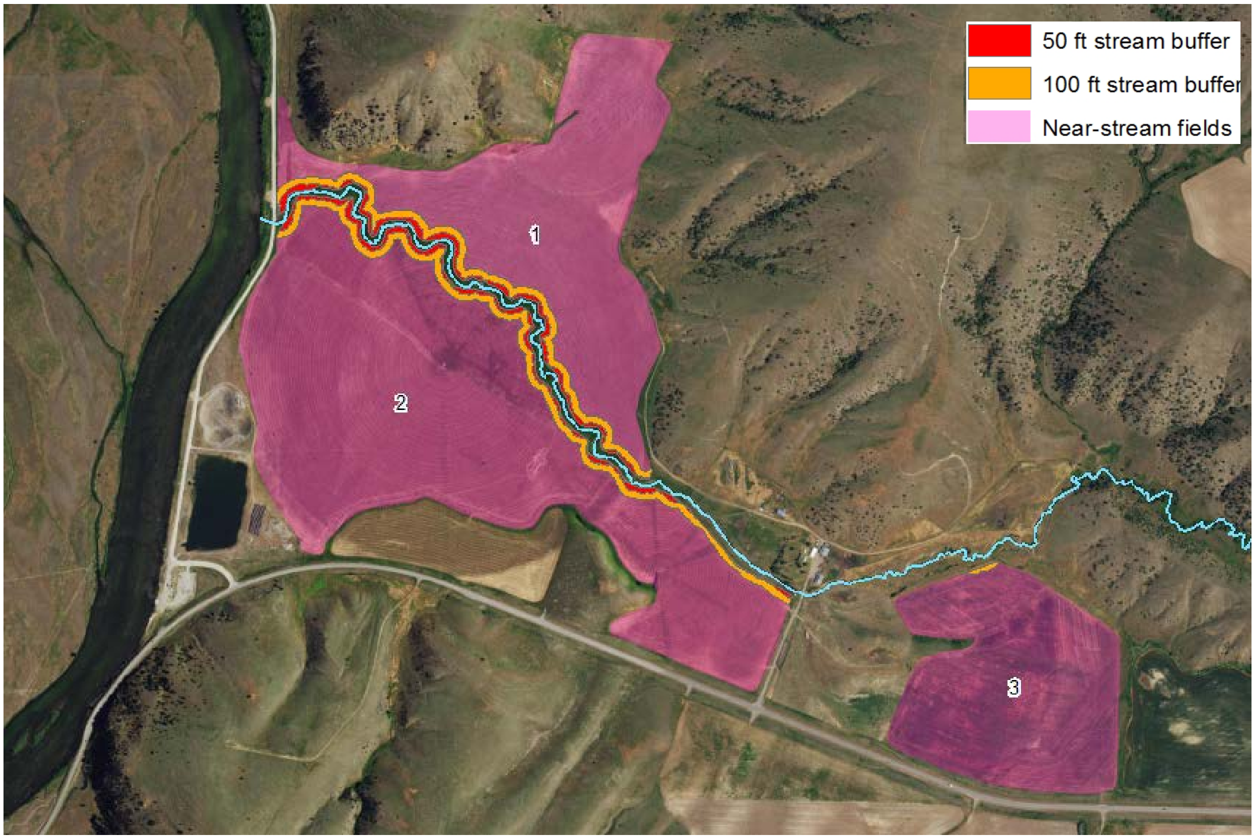

Figure E-2. Elk Creek fields 1-3, with 50 and 100-foot buffers

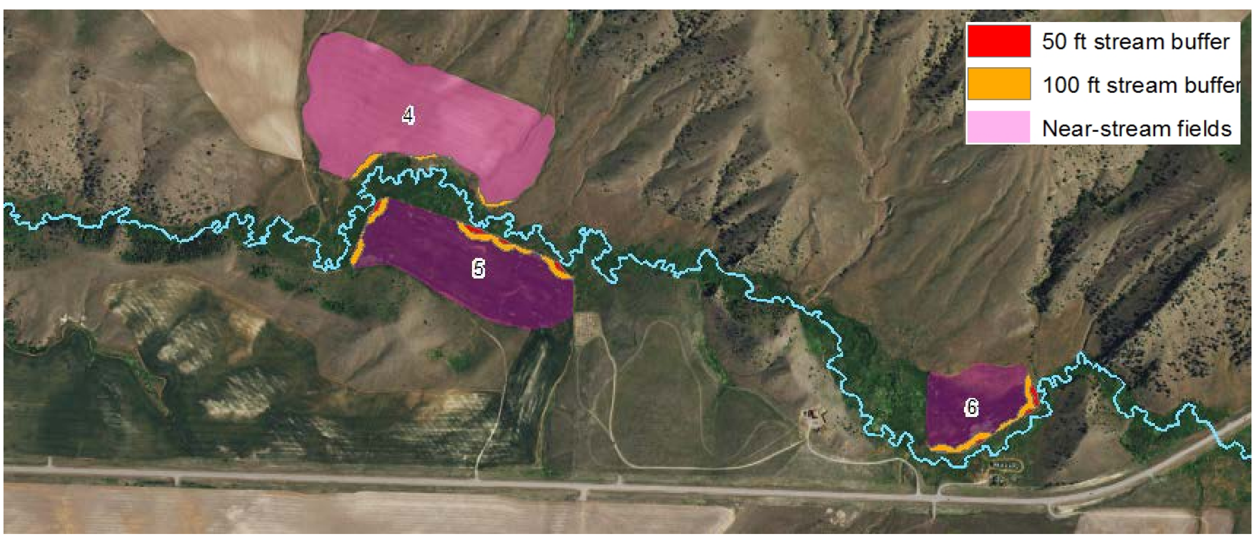

Figure E-3. Elk Creek fields 4-6, with 50 and 100-foot buffers

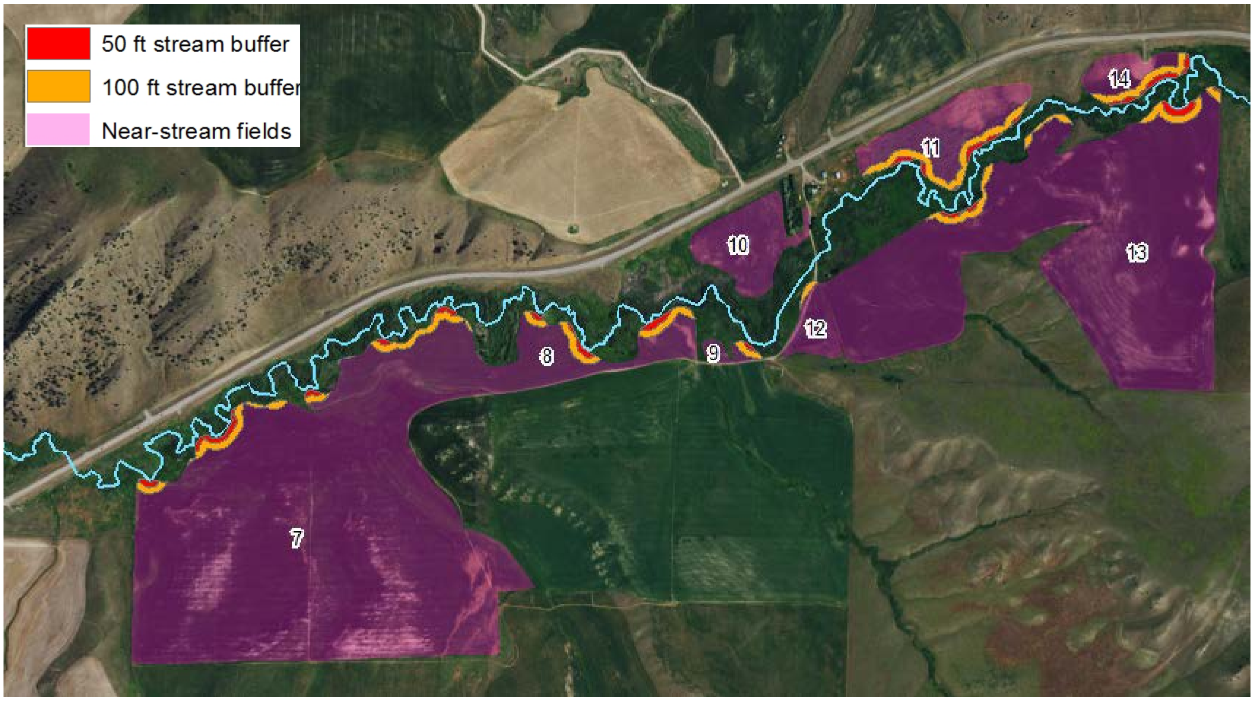

Figure E-4. Elk Creek fields 7-14, with 50 and 100-foot buffers

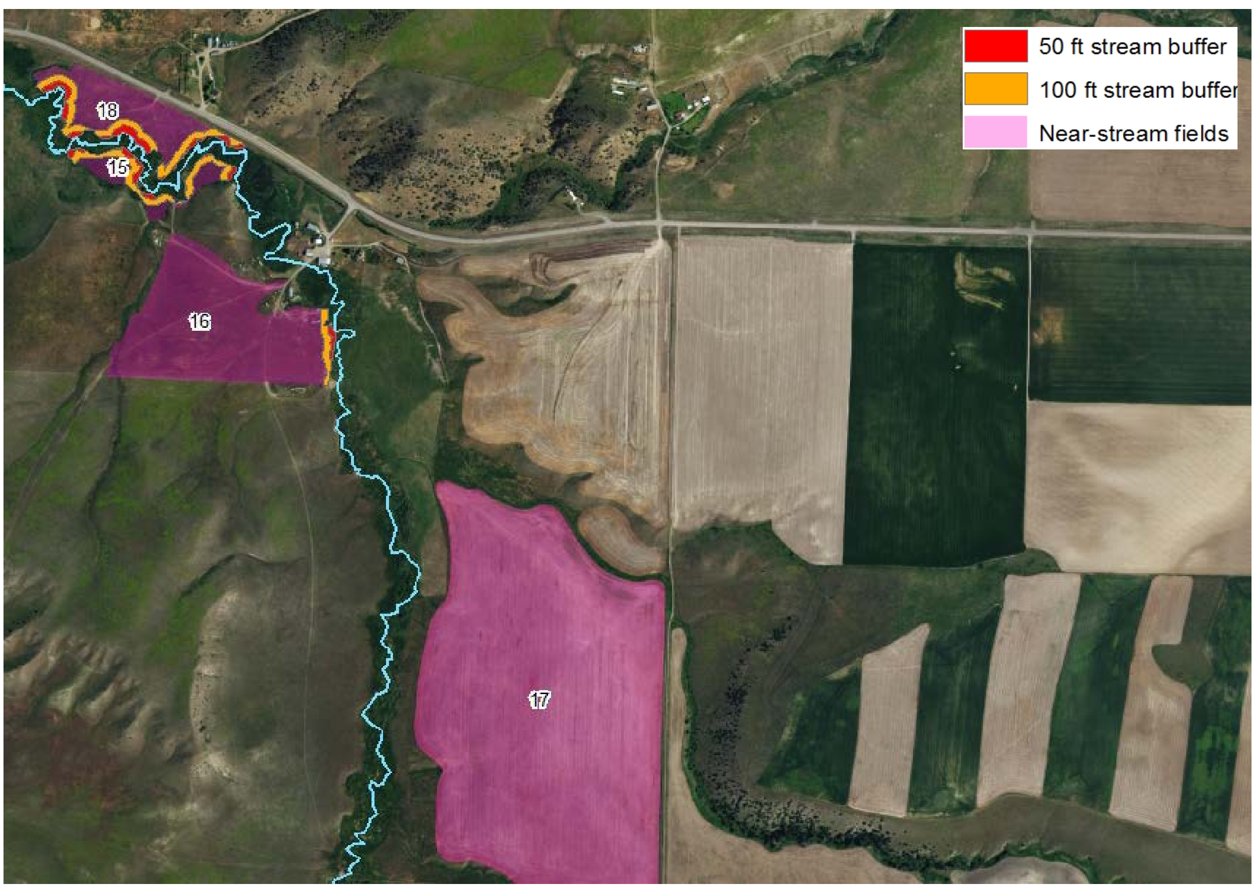

Figure E-5. Elk Creek fields 15-18, with 50 and 100-foot buffers

E2.0 SEDIMENT CONTRIBUTION FROM CULTIVATED FIELDS

To analyze the contribution of sediment from these fields to the stream, hillslope erosion was estimated using loading rates estimated for cultivated fields in the Boulder-Elkhorn watershed. The majority of cultivated fields in the Boulder-Elkhorn USLE assessment area reside in the same ecoregion as the near-stream agricultural fields in the Elk Creek watershed (Ecoregion IV – Townsend Basin) (**Figure E-6**).

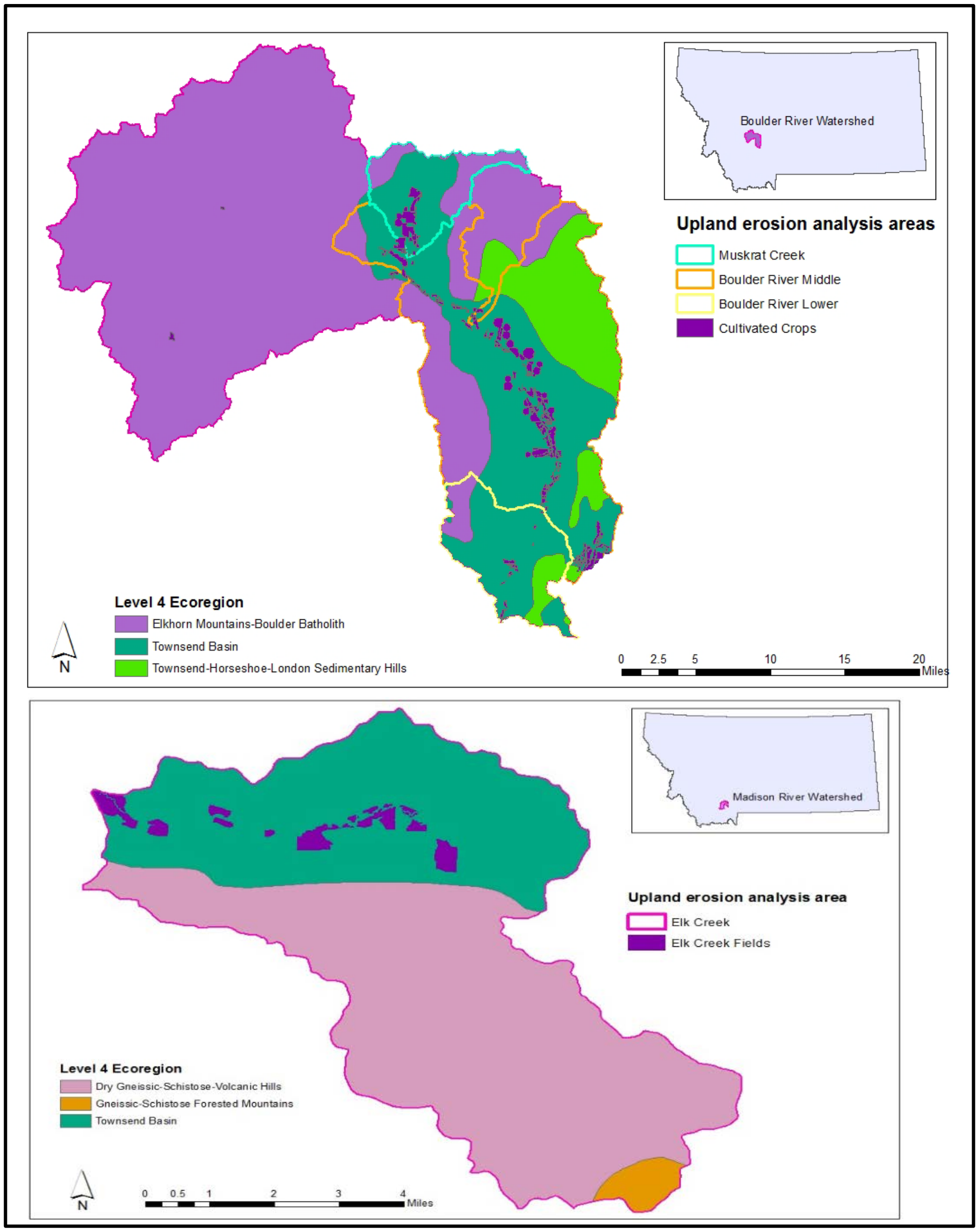

Figure E-6. Ecoregion comparison of Boulder valley agricultural area and Elk Creek near-stream fields.

The Boulder-Elkhorn assessment used the Universal Soil Loss Equation (USLE) to estimate existing sediment loads from cultivated fields and sediment loads from cultivated fields after the application of upland best management practices (a 20% increase in ground cover over existing conditions). In order to predict how much of these existing and BMP sediment loads from cultivated fields made it to the stream, existing and potential conditions of the 100 foot riparian buffer were taken into account. To learn more about how erosion from cultivated fields was calculated in the Boulder-Elkhorn watershed, refer to Attachment 2 of the *Boulder-Elkhorn Sediment, Nutrients and Temperature TMDLs and Water Quality Improvement Plans, September 2013* document.

Erosion rates calculated for cultivated fields in the Muskrat Creek, Boulder River Middle, and Boulder River Lower subwatersheds were averaged (**Table E-1**) and this average was used for fields in the Elk Creek watershed to estimate sediment loading rates before and after BMP's.

Table E-1. Estimated field sediment loads and erosion rates for cultivated fields in the Muskrat Creek, Middle Boulder River, and Lower Boulder River watersheds.

Boulder-Elkhorn Subwatersheds		**Cultivated Fields - Existing Sediment Loads and Erosion Rates**		**Cultivated Fields - BMP Sediment Loads and Erosion Rates**	
	Area (acres)	Tons/year	Avg. tons/acre/year	Tons/year	Avg. tons/acre/year
Muskrat Creek	225	7.7	0.034	3.8	0.017
Boulder River Middle	1,001.90	31.6	0.032	15.8	0.016
Boulder River Lower	10.7	0.5	0.047	0.25	0.023
Avg. erosion rate			**0.037**		**0.019**

E3.0 Riparian Health Assessment

Well-vegetated riparian buffers have been shown to act as filters that remove sediment from overland flow. Because of this ability, the influence of riparian corridors on water quality is proportionately much greater than the relatively small area in the landscape they occupy. In general, the effectiveness of vegetated riparian buffers is proportional to their width and overall health. Thus, information regarding riparian zone health can be used to refine estimates of sediment delivery to streams from upstream sources.

A literature review (Wengner 1999, Knutson and Naef 1997) indicated that a 100 foot wide, well-vegetated riparian buffer zone can be expected to filter 75-90% of incoming sediment from reaching its stream channel. Accordingly, this analysis conservatively assumes that a sediment reduction efficiency of 75% represents the performance of a 100 foot wide, high quality (good) vegetated riparian buffer on Elk Creek. Conversely, this analysis conservatively assumes that a 100 foot wide riparian zone without vegetation cover would only filter 10% of incoming sediment from reaching its stream. An approximately equal apportionment of the remaining range in sediment reduction efficiency between the 'poor', 'moderately fair, 'fair', and 'moderately good' riparian assessment categories results in the riparian health/sediment delivery relationship shown in **Figure E-7**.

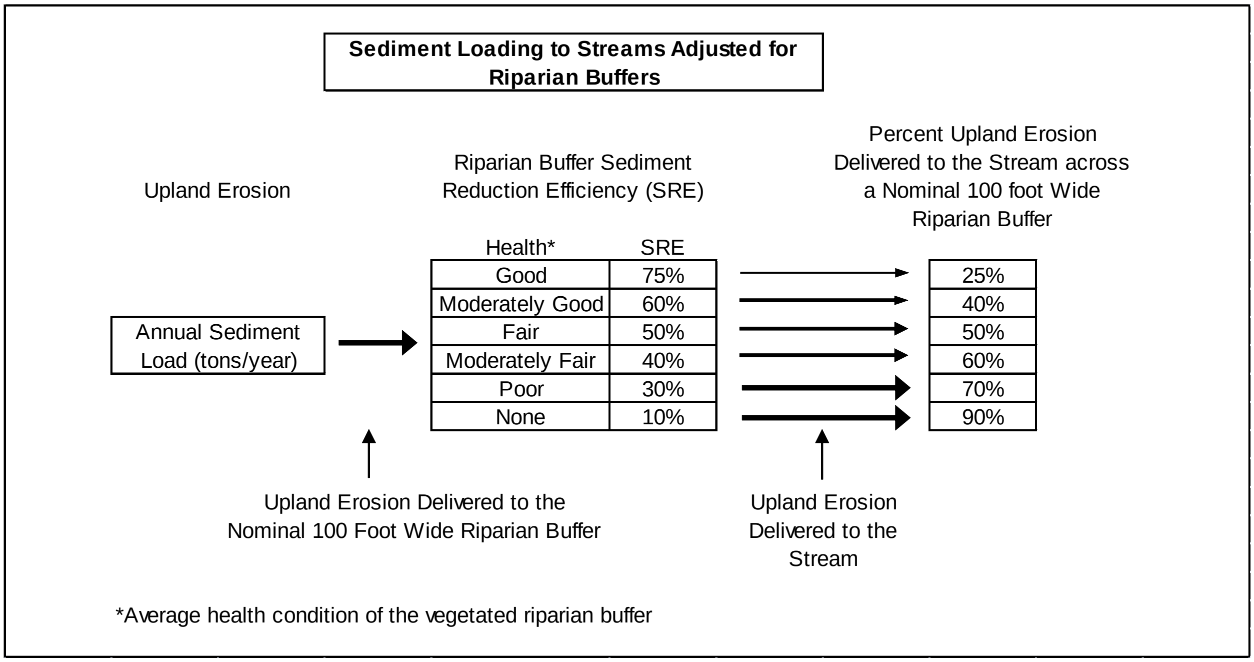

Figure E-7. USLE upland sediment load delivery adjusted for riparian buffer capacity

These load adjustments, based on the condition of the 100 foot buffer, were applied to the existing sediment load from near-stream fields in order to get a total existing load delivered to the stream (**Table E-2**). A potential load after implementing riparian BMP's was estimated by increasing the buffer efficiency by 20% with a total proportion entering the stream no less than 25% which is the value considered attainable once reasonable BMP's have been put in place (**Table E-3**).

Table E-2 Estimated load delivered by agricultural fields to the stream based on existing field conditions and buffer quality

Field No	Acres	Existing Field Load (Tons/Year)	Existing Buffer Efficiency (Proportion Entering Stream)	Existing Load Delivered to Stream (Tons/Year) = Existing Field Load * Proportion Entering Stream
1	76	2.81	Poor (0.70)	1.97
2	132	4.88	Poor (0.70)	3.42
3	52	1.92	Poor (0.70)	1.35
4	32	1.18	Moderate-Fair (0.60)	0.71
5	20	0.74	Moderate-Fair (0.60)	0.44
6	10	0.37	Moderate-Fair (0.60)	0.22
7	104	3.85	Moderate-Fair (0.60)	2.31
8	20	0.74	Moderate-Fair (0.60)	0.44
9	1	0.04	Moderate-Fair (0.60)	0.02
10	>100 Foot Buffer Already Present			
11	11	0.41	Moderate-Fair (0.60)	0.24
12	3	0.11	Fair (0.50)	0.06
13	80	2.96	Moderate-Good (0.40)	1.18

Table E-2 Estimated load delivered by agricultural fields to the stream based on existing field conditions and buffer quality

Field No	Acres	Existing Field Load (Tons/Year)	Existing Buffer Efficiency (Proportion Entering Stream)	Existing Load Delivered to Stream (Tons/Year) = Existing Field Load * Proportion Entering Stream
14	5	0.19	Moderate-Fair (0.60)	0.11
15	5	0.19	Fair (0.50)	0.09
16	28	1.04	Poor (0.70)	0.73
17	>100 Foot Buffer Already Present			
18	11	0.41	Fair (0.50)	0.20
Total	590	21.83		13.50

Table E-3. Potential changes in buffer quality of agricultural fields in the Elk Creek Watershed after implementing BMPs.

FieldNo	Existing Buffer Quality Proportion Entering Stream	Potential Buffer Proportion Entering Stream
1	Poor (0.70)	Fair (0.50)
2	Poor (0.70)	Fair (0.50)
3	Poor (0.70)	Fair (0.50)
4	Moderate-Fair (0.60)	Moderate-Good (0.40)
5	Moderate-Fair (0.60)	Moderate-Good (0.40)
6	Moderate-Fair (0.60)	Moderate-Good (0.40)
7	Moderate-Fair (0.60)	Moderate-Good (0.40)
8	Moderate-Fair (0.60)	Moderate-Good (0.40)
9	Moderate-Fair (0.60)	Moderate-Good (0.40)
11	Moderate-Fair (0.60)	Moderate-Good (0.40)
12	Fair (0.50)	Good (0.30)
13	Moderate-Good (0.40)	Good (0.25)
14	Moderate-Fair (0.60)	Moderate-Good (0.40)
15	Fair (0.50)	Good (0.30)
16	Poor (0.70)	Fair (0.50)
18	Fair (0.50)	Good (0.30)

E4.0 Management Scenarios and Sediment Load Reductions

To determine the potential reduction in sediment entering streams after implementing BMP's, the following equations were applied, using estimated erosion rates from Tables E-1 and E-3.

Scenario 1:
BMP Field Load (Existing Buffer) = Acres * Average Erosion Rate (with BMPs) * Upland Erosion Rate (with Existing Buffer Quality)

Scenario 2:
Existing Field Load (BMP Buffer)=Acres * Average Erosion Rate (without BMPs) * Upland Erosion Rate (with Potential BMP Buffer Quality)

Scenario 3: BMP Field Load (BMP Buffer)
Acres * Average Erosion Rate (with BMP's) * Upland Erosion Rate (with Potential BMP Buffer Quality)

The following table (**Table E-4**) provides an estimate of existing sediment loading from agricultural fields and estimates of potential sediment loading reductions that could be achieved through the three scenarios.

Table E-4. Estimated reduction in sediment in the Elk Creek watershed with 3 BMP scenarios.

							Scenario 1		Scenario 2		Scenario 3	
FieldNo	**Acres**	**Existing Field Load in Tons/year**	**Potential BMP Field Load**	**Existing Buffer quality (Erosion Rate)**	**Potential buffer Quality (Erosion Rate)**	**Existing Load Delivered to Stream (Tons/Yr)**	**Upland BMP Only (Tons/Yr)**	**% Change from Existing Load**	**Buffer BMP Only**	**% Change from Existing Load**	**Upland and Buffer BMP (Tons /Yr)**	**% Change from Existing Load**
1	76	2.81	1.44	Poor (0.70)	Fair (0.50)	1.97	1.01	49%	1.41	29%	0.72	63%
2	132	4.88	2.51	Poor (0.70)	Fair (0.50)	3.42	1.76	49%	2.44	29%	1.25	63%
3	52	1.92	0.99	Poor (0.70)	Fair (0.50)	1.35	0.69	49%	0.96	29%	0.49	63%
4	32	1.18	0.61	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.71	0.36	49%	0.47	33%	0.24	66%
5	20	0.74	0.38	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.44	0.23	49%	0.30	33%	0.15	66%
6	10	0.37	0.19	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.22	0.11	49%	0.15	33%	0.08	66%
7	104	3.85	1.98	Moderate-Fair (0.60)	Moderate-Good (0.40)	2.31	1.19	49%	1.54	33%	0.79	66%
8	20	0.74	0.38	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.44	0.23	49%	0.30	33%	0.15	66%
9	1	0.04	0.02	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.02	0.01	49%	0.01	33%	0.01	66%
11	11	0.41	0.21	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.24	0.13	49%	0.16	33%	0.08	66%
12	3	0.11	0.06	Fair (0.50)	Good (0.30)	0.06	0.03	49%	0.03	40%	0.02	69%
13	80	2.96	1.52	Moderate-Good (0.40)	Good (0.25)	1.18	0.61	49%	0.89	25%	0.46	61%
14	5	0.19	0.10	Moderate-Fair (0.60)	Moderate-Good (0.40)	0.11	0.06	49%	0.07	33%	0.04	66%
15	5	0.19	0.10	Fair (0.50)	Good (0.30)	0.09	0.05	49%	0.06	40%	0.03	69%
16	28	1.04	0.53	Poor (0.70)	Fair (0.50)	0.73	0.37	49%	0.52	29%	0.27	63%

Table E-4. Estimated reduction in sediment in the Elk Creek watershed with 3 BMP scenarios.

							Scenario 1		Scenario 2		Scenario 3	
FieldNo	**Acres**	**Existing Field Load in Tons/year**	**Potential BMP Field Load**	**Existing Buffer quality (Erosion Rate)**	**Potential buffer Quality (Erosion Rate)**	**Existing Load Delivered to Stream (Tons/Yr)**	**Upland BMP Only (Tons/Yr)**	**% Change from Existing Load**	**Buffer BMP Only**	**% Change from Existing Load**	**Upland and Buffer BMP (Tons /Yr)**	**% Change from Existing Load**
18	11	0.41	0.21	Fair (0.50)	Good (0.30)	0.20	0.10	49%	0.12	40%	0.06	69%
Total	**590**	**21.83**	**11.21**			**13.50**	**6.93**	**49%**	**9.43**	**30%**	**4.84**	**64%**

E5.0 References

Knutson, K. L. and V. L. Naef. 1997. Management recommendations for Washington's priority habitats: riparian. Washington Department of Fish and Wildlife, Olympia, WA. 181 pp.

DEQ (Montana Department of Environmental Quality). 2012. Final Boulder-Elkhorn Metals TMDLs and Framework Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent and vegetation. Office of Public Service and Outreach, Institute of Ecology, University of Georgia, Athens, GA.