APPENDIX F

Erosion and Sediment Load Estimation

EROSION AND SEDIMENT LOAD ESTIMATION

For the purposes of this analysis, we have defined erosion as the process by which soil particles are mobilized and sediment load is the amount of eroded material that enters a stream channel. Sediment delivery ratio is the fraction of eroded material that enters a stream as the sediment load. While erosion can occur due to the action of wind, water, or glaciers, the Soils and Water Resources sections of this report are primarily concerned with erosion caused by water. Erosion was assumed to occur from four sources: 1) general soil erosion occurring throughout the watersheds, 2) well pads and facilities, 3) roads at stream crossings, and 4) roads throughout the remainder of the MBPA. The sediment load was assumed to occur from three sources: 1) general soil erosion occurring throughout the watersheds, 2) well pads and facilities, and 3) roads at stream crossings. It was assumed that sediment eroded from roads that were greater than 300 feet from a stream did not reach the stream and therefore, was not considered as a sediment load to the stream.

General soil erosion was estimate by acquiring sediment yield coefficients from a literature search on studies that were performed in northeast Utah. From these studies, we were able to estimate the sediment yield from combinations of vegetation and soil erodibility. The vegetation types were obtained from vegetation maps discussed in **Section 3.7** of this EIS. Soil erodibility categories (Low, Medium, and High) were generated from Water Erosion Potential values obtained from the Natural Resources Conservation Service (NRCS) GIS database. While sediment yield is a measure of the quantity of soil delivered to a watershed's stream, in this case we are also assuming that the watershed's sediment yield is also the amount of erosion occurring in the watershed. **Table F-1** provides a list of the sediment yield coefficients used in the analysis. **Tables F-2** through **F-5** show the general watershed erosion and sediment load occurring in each watershed.

F-1. Sediment Yield Coefficient

Land Cover	Soil Erodibility	Sediment Yield Coefficient (acre-feet/sq.mi./year)
Pinyon Juniper	Low	0.2
Riparian	Low	0.1
Sagebrush	Low	0.3
Desert Shrub	Low	0.4
Badlands	Low	0.5
Pinyon Juniper	Medium	0.4
Riparian	Medium	0.2
Sagebrush	Medium	0.6
Desert Shrub	Medium	0.9
Badlands	Medium	1.2
Pinyon Juniper	High	0.7
Riparian	High	0.3
Sagebrush	High	1.0
Desert Shrub	High	1.5
Badlands	High	2.0
Water or Rock	-	0.0

F-2. Erosion and Sediment Yield from General Erosion for Antelope Creek Watershed

Land Cover	Soil Erodibility	Area (acres)	Sediment Yield Coefficient (acre-feet/sq.mi./year)	Sediment Yield (tons/year)	Delivery Ratio	Erosion (tons/year)
Pinyon Juniper	Low	-	0.2	0	100%	0
Riparian	Low	-	0.1	0	100%	0
Sagebrush	Low	35	0.3	32	100%	32
Desert Shrub	Low	105	0.4	129	100%	129
Badlands	Low	-	0.5	0	100%	0
Pinyon Juniper	Medium	-	0.4	0	100%	0
Riparian	Medium	-	0.2	0	100%	0
Sagebrush	Medium	-	0.6	0	100%	0
Desert Shrub	Medium	10	0.9	28	100%	28
Badlands	Medium	-	1.2	0	100%	0
Pinyon Juniper	High	-	0.7	0	100%	0
Riparian	High	-	0.3	0	100%	0
Sagebrush	High	-	1.0	0	100%	0
Desert Shrub	High	-	1.5	0	100%	0
Badlands	High	-	2.0	0	100%	0
Water or Rock	-	-	0.0	0	100%	0
Total	**-**	**151**	**-**	**189**	**-**	**189**

Assume that soil density is 90 lbs. per cubic foot.

Table F-3. Erosion and Sediment Yield from General Erosion for Upper Pariette Draw Watershed

Land Cover	Soil Erodibility	Area (acres)	Adjusted Area (1) (acres)	Sediment Yield Coefficient (acre-feet/sq.mi./year)	Sediment Yield (tons/year)	Delivery Ratio	Erosion (tons/year)
Pinyon Juniper	Low	3,847	3,847	0.2	2,356	100%	2,356
Riparian	Low	-	-	0.1	0	100%	0
Sagebrush	Low	14,032	14,032	0.3	12,893	100%	12,893
Desert Shrub	Low	11,011	11,011	0.4	13,490	100%	13,490
Badlands	Low	914	914	0.5	1,400	100%	1,400
Pinyon Juniper	Medium	0	0	0.4	0	100%	0
Riparian	Medium	-	-	0.2	0	100%	0
Sagebrush	Medium	1,060	1,060	0.6	1,949	100%	1,949
Desert Shrub	Medium	9,874	9,874	0.9	27,217	100%	27,217
Badlands	Medium	19	19	1.2	72	100%	72
Pinyon Juniper	High	-	-	0.7	0	100%	0
Riparian	High	-	-	0.3	0	100%	0
Sagebrush	High	-	-	1.0	0	100%	0
Desert Shrub	High	22	22	1.5	102	100%	102
Badlands	High	-	-	2.0	0	100%	0
Water or Rock	-	-	65	0.0	0	100%	0
Total	**-**	**40,780**	**40,845**	**-**	**59,479**	**-**	**59,479**

(1) The individual areas did not sum to the total area of the watershed so the areas were adjusted.
Assume that soil density is 90 lbs. per cubic foot.

Table F-4. Erosion and Sediment Yield from General Erosion for Sheep Wash-Green River Watershed

Land Cover	Soil Erodibility	Area (acres)	Adjusted Area (1) (acres)	Sediment Yield Coefficient (acre-feet/sq.mi./year)	Sediment Yield (tons/year)	Delivery Ratio	Erosion (tons/year)
Pinyon Juniper	Low	-	-	0.2	0	100%	0
Riparian	Low	3	3	0.1	1	100%	1
Sagebrush	Low	338	338	0.3	311	100%	311
Desert Shrub	Low	3,384	3,384	0.4	4,146	100%	4,146
Badlands	Low	398	398	0.5	610	100%	610
Pinyon Juniper	Medium	-	-	0.4	0	100%	0
Riparian	Medium	13	13	0.2	8	100%	8
Sagebrush	Medium	63	63	0.6	116	100%	116
Desert Shrub	Medium	6,336	6,336	0.9	17,466	100%	17,466
Badlands	Medium	46	46	1.2	170	100%	170
Pinyon Juniper	High	-	-	0.7	0	100%	0
Riparian	High	-	-	0.3	0	100%	0
Sagebrush	High	-	-	1.0	0	100%	0
Desert Shrub	High	-	-	1.5	0	100%	0
Badlands	High	-	-	2.0	0	100%	0
Water or Rock	-	14	35	0.0	0	100%	0
Total	**-**	**10,596**	**10,617**	**-**	**22,827**	**-**	**22,827**

(1) The individual areas did not sum to the total area of the watershed so the areas were adjusted.
Assume that soil density is 90 lbs. per cubic foot.

Table F-5. Erosion and Sediment Yield from General Erosion for Lower Pariette Draw Watershed

Land Cover	Soil Erodibility	Area (acres)	Adjusted Area (1) (acres)	Sediment Yield Coefficient (acre-feet/sq.mi./year)	Sediment Yield (tons/year)	Delivery Ratio	Erosion (tons/year)
Pinyon Juniper	Low	2	2	0.2	1	100%	1
Riparian	Low	-	-	0.1	0	100%	0
Sagebrush	Low	19,137	19,137	0.3	17,584	100%	17,584
Desert Shrub	Low	16,908	16,908	0.4	20,714	100%	20,714
Badlands	Low	2,329	2,329	0.5	3,567	100%	3,567
Pinyon Juniper	Medium	-	-	0.4	0	100%	0
Riparian	Medium	-	-	0.2	0	100%	0
Sagebrush	Medium	1,742	1,742	0.6	3,201	100%	3,201
Desert Shrub	Medium	27,255	27,255	0.9	75,130	100%	75,130
Badlands	Medium	555	555	1.2	2,039	100%	2,039
Pinyon Juniper	High	-	-	0.7	0	100%	0
Riparian	High	-	-	0.3	0	100%	0
Sagebrush	High	-	-	1.0	0	100%	0
Desert Shrub	High	-	-	1.5	0	100%	0
Badlands	High	-		2.0	0	100%	0
Water or Rock	-	148	202	0.0	0	100%	0
Total	-	**68,077**	**68,131**	-	**122,237**	-	**122,237**

(1) The individual areas did not sum to the total area of the watershed so the areas were adjusted.
Assume that soil density is 90 lbs. per cubic foot.

Created by the NRCS, the Revised Universal Soil Loss Equation 2 (RUSLE2) computer program was used to estimate erosion from well pads. A typical well pad configuration was developed. Each well pad was assumed to be 475 feet long by 225 feet wide with a one percent slope. There was assumed to be five-foot high cut slope at a 3:1 slope at one end and a five-foot high fill slope at a 3:1 slope at the other end. The erosion from the pad was estimated for pads located on the four soil types found in the GMPA: loam, silt loam, sandy loam, and clay loam. It was assumed that all pads were constructed using the required erosion and sediment control Best Management Practices (BMPs), including a berm along the top edge of the pad and a sedimentation basin to capture sediment before it leaves the site. The RUSLE2 program estimated the erosion from the pad and also the reduction of the sediment load due to the BMPs that will be used. The typical pad erosion and sediment load estimate from each soil type was multiplied by the total number of pads located in a particular soil type and in each watershed to obtain an estimate of the erosion and sediment load in each watershed.

In addition, some existing pads will be expanded. It was assumed that the typical pad expansion would be about 0.2 acres or about 10 percent of the area of a new pad. It was assumed that the erosion and sediment load rate was proportional to the area of the pad; therefore, the erosion and sediment load from the portion of the new expanded pad was assumed to be 10 percent of a new pad. It was assumed that there would be no erosion or sediment load from existing pads because they would have undergone interim reclamation. Disturbed areas would have either been revegetated or graveled, so there would essentially be no erosion from the site. **Tables F-6** through **F-9** provide the estimated erosion and sediment load from well pads in each watershed.

Table F-6. Sediment Yield from Pad Erosion per Watershed for Alternative A

Watershed	Soil Type	# of New Pads	# of Expanded Pads	Erosion per Pad for New Pads (1) (tons/year)	Erosion per Pad for Expanded Pads (2) (tons/year)	Length of Construction and Development Phase (years)	Erosion (3) (tons/year)	Sediment Delivery From Each New Pad (tons/year)	Sediment Delivery From Each Expanded Pad (tons/year)	Total Sediment Delivery from Pads (tons/year)	Delivery Ratio To Stream (4)	Sediment Yield To Stream (tons/year)
Antelope Creek	Loam	0	0	0.044	0.0044	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Antelope Creek	Clay Loam	0	0	0.024	0.0024	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Antelope Creek	Silty Loam	0	0	0.059	0.0059	16	0.00	0.0029	0.0003	0.0000	0.1	0.000
Antelope Creek	Sandy Loam	4		0.039	0.0039	16	0.01	0.0010	0.0001	0.0003	0.1	0.000
Subtotal		4	0				0.01			0.0003		0.000
Lower Pariette Draw	Loam	185	166	0.044	0.0044	16	0.55	0.0019	0.0002	0.0243	0.1	0.002
Lower Pariette Draw	Clay Loam	18	19	0.024	0.0024	16	0.03	0.0019	0.0002	0.0023	0.1	0.000
Lower Pariette Draw	Silty Loam	108	49	0.059	0.0059	16	0.41	0.0029	0.0003	0.0207	0.1	0.002
Lower Pariette Draw	Sandy Loam	405	546	0.039	0.0039	16	1.12	0.0010	0.0001	0.0288	0.1	0.003
Subtotal		716	780				2.12			0.0761		0.008
Sheep Wash-Green River	Loam	51	3	0.044	0.0044	16	0.14	0.0019	0.0002	0.0062	0.1	0.001
Sheep Wash-Green River	Clay Loam	19	8	0.024	0.0024	16	0.03	0.0019	0.0002	0.0023	0.1	0.000
Sheep Wash-Green River	Silty Loam	34	7	0.059	0.0059	16	0.13	0.0029	0.0003	0.0064	0.1	0.001
Sheep Wash-Green River	Sandy Loam	98	11	0.039	0.0039	16	0.24	0.0010	0.0001	0.0062	0.1	0.001
Subtotal		202	29				0.54			0.0211		0.002
Upper Pariette Draw	Loam	68	101	0.044	0.0044	16	0.21	0.0019	0.0002	0.0094	0.1	0.001
Upper Pariette Draw	Clay Loam	5	6	0.024	0.0024	16	0.01	0.0019	0.0002	0.0007	0.1	0.000
Upper Pariette Draw	Silty Loam	26	31	0.059	0.0059	16	0.11	0.0029	0.0003	0.0053	0.1	0.001
Upper Pariette Draw	Sandy Loam	302	457	0.039	0.0039	16	0.85	0.0010	0.0001	0.0218	0.1	0.002
Subtotal		401	595				1.18			0.0372		0.004
Total		**1323**	**1404**				**3.85**			**0.1346**		**0.013**

(1) Assumes that typical pad area size is 2.45 acres
(2) Assumes that expanded area is about 10% of the new pad area so erosion is 10% that of new pad.
(3) Assumes that 1/16th of the total number of wells are constructed each year during the construction and development phase and that each well pad is “disturbed” for one (1) year until it is reclaimed and additional erosion over background erosion ceases.
(4) Assumes that 10% of the sediment leaving the pad site is delivered to a stream.
One pad location is located on ‘No Soil’.

Table F-7. Sediment Yield from Pad Erosion per Watershed for Alternative B

Watershed	Soil Type	# of New Pads	# of Expanded Pads	Erosion per Pad for New Pads (1) (tons/year)	Erosion per Pad for Expanded Pads (2) (tons/year)	Length of Construction and Development Phase (years)	Erosion (3) (tons/year)	Sediment Delivery From Each New Pad (tons/year)	Sediment Delivery From Each Expanded Pad (tons/year)	Total Sediment Delivery from Pads (tons/year)	Delivery Ratio To Stream (4)	Sediment Yield To Stream (tons/year)
Antelope Creek	Loam	0	0	0.044	0.0044	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Antelope Creek	Clay Loam	0	0	0.024	0.0024	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Antelope Creek	Silty Loam	0	0	0.059	0.0059	16	0.00	0.0029	0.0003	0.0000	0.1	0.000
Antelope Creek	Sandy Loam	0	0	0.039	0.0039	16	0.00	0.0010	0.0001	0.0000	0.1	0.000
Subtotal		0	0				0.00			0.0000		0.000
Lower Pariette Draw	Loam	13	20	0.044	0.0044	16	0.04	0.0019	0.0002	0.0018	0.1	0.000
Lower Pariette Draw	Clay Loam	7	13	0.024	0.0024	16	0.01	0.0019	0.0002	0.0010	0.1	0.000
Lower Pariette Draw	Silty Loam	0	6	0.059	0.0059	16	0.00	0.0029	0.0003	0.0001	0.1	0.000
Lower Pariette Draw	Sandy Loam	49	117	0.039	0.0039	16	0.15	0.0010	0.0001	0.0038	0.1	0.000
Subtotal		69	156				0.20			0.0067		0.001
Sheep Wash-Green River	Loam	7		0.044	0.0044	16	0.02	0.0019	0.0002	0.0008	0.1	0.000
Sheep Wash-Green River	Clay Loam			0.024	0.0024	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Sheep Wash-Green River	Silty Loam			0.059	0.0059	16	0.00	0.0029	0.0003	0.0000	0.1	0.000
Sheep Wash-Green River	Sandy Loam	12		0.039	0.0039	16	0.03	0.0010	0.0001	0.0008	0.1	0.000
Subtotal		19	0				0.05			0.0016		0.000
Upper Pariette Draw	Loam	21	40	0.044	0.0044	16	0.07	0.0019	0.0002	0.0030	0.1	0.000
Upper Pariette Draw	Clay Loam	2	4	0.024	0.0024	16	0.00	0.0019	0.0002	0.0003	0.1	0.000
Upper Pariette Draw	Silty Loam	0	7	0.059	0.0059	16	0.00	0.0029	0.0003	0.0001	0.1	0.000
Upper Pariette Draw	Sandy Loam	17	83	0.039	0.0039	16	0.06	0.0010	0.0001	0.0016	0.1	0.000
Subtotal		40	134				0.14			0.0050		0.001
Total		**128**	**290**				**0.39**			**0.0133**		**0.001**

(1) Assumes that typical pad area size is 2.45 acres
(2) Assumes that expanded area is about 10% of the new pad area so erosion is 10% that of new pad.
(3) Assumes that 1/16th of the total number of wells are constructed each year during the construction and development phase and that each well pad is “disturbed” for one (1) year until it is reclaimed and additional erosion over background erosion ceases.
(4) Assumes that 10% of the sediment leaving the pad site is delivered to a stream.
One pad location is located on ‘No Soil’.

Table F-8. Sediment Yield from Pad Erosion per Watershed for Alternative C

Watershed	Soil Type	# of New Pads	# of Expanded Pads	Erosion per Pad for New Pads (1) (tons/year)	Erosion per Pad for Expanded Pads (2) (tons/year)	Length of Construction and Development Phase (years)	Erosion (3) (tons/year)	Sediment Delivery From Each New Pad (tons/year)	Sediment Delivery From Each Expanded Pad (tons/year)	Total Sediment Delivery from Pads (tons/year)	Delivery Ratio To Stream (4)	Sediment Yield To Stream (tons/year)
Antelope Creek	Loam	0	0	0.044	0.0044	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Antelope Creek	Clay Loam	0	0	0.024	0.0024	16	0.00	0.0019	0.0002	0.0000	0.1	0.000
Antelope Creek	Silty Loam	0	0	0.059	0.0059	16	0.00	0.0029	0.0003	0.0000	0.1	0.000
Antelope Creek	Sandy Loam	4		0.039	0.0039	16	0.01	0.0010	0.0001	0.0003	0.1	0.000
Subtotal		4	0				0.01			0.0003		0.000
Lower Pariette Draw	Loam	185	166	0.044	0.0044	16	0.55	0.0019	0.0002	0.0243	0.1	0.002
Lower Pariette Draw	Clay Loam	18	19	0.024	0.0024	16	0.03	0.0019	0.0002	0.0023	0.1	0.000
Lower Pariette Draw	Silty Loam	108	49	0.059	0.0059	16	0.41	0.0029	0.0003	0.0207	0.1	0.002
Lower Pariette Draw	Sandy Loam	405	546	0.039	0.0039	16	1.12	0.0010	0.0001	0.0288	0.1	0.003
Subtotal		716	780				2.12			0.0761		0.008
Sheep Wash-Green River	Loam	51	3	0.044	0.0044	16	0.14	0.0019	0.0002	0.0062	0.1	0.001
Sheep Wash-Green River	Clay Loam	19	8	0.024	0.0024	16	0.03	0.0019	0.0002	0.0023	0.1	0.000
Sheep Wash-Green River	Silty Loam	34	7	0.059	0.0059	16	0.13	0.0029	0.0003	0.0064	0.1	0.001
Sheep Wash-Green River	Sandy Loam	98	11	0.039	0.0039	16	0.24	0.0010	0.0001	0.0062	0.1	0.001
Subtotal		202	29				0.54			0.0211		0.002
Upper Pariette Draw	Loam	68	101	0.044	0.0044	16	0.21	0.0019	0.0002	0.0094	0.1	0.001
Upper Pariette Draw	Clay Loam	5	6	0.024	0.0024	16	0.01	0.0019	0.0002	0.0007	0.1	0.000
Upper Pariette Draw	Silty Loam	26	31	0.059	0.0059	16	0.11	0.0029	0.0003	0.0053	0.1	0.001
Upper Pariette Draw	Sandy Loam	302	457	0.039	0.0039	16	0.85	0.0010	0.0001	0.0218	0.1	0.002
Subtotal		401	595				1.18			0.0372		0.004
Total		**1323**	**1404**				**3.85**			**0.1346**		**0.013**

(1) Assumes that typical pad area size is 2.45 acres
(2) Assumes that expanded area is about 10% of the new pad area so erosion is 10% that of new pad.
(3) Assumes that 1/16th of the total number of wells are constructed each year during the construction and development phase and that each well pad is “disturbed” for one (1) year until it is reclaimed and additional erosion over background erosion ceases.
(4) Assumes that 10% of the sediment leaving the pad site is delivered to a stream.
One pad location is located on ‘No Soil’.

Table F-9. Sediment Yield from Pad Erosion per Watershed for Alternative D

Watershed	Soil Type	# of New Pads	# of Expanded Pads	Erosion per Pad for New Pads (1) (tons/year)	Erosion per Pad for Expanded Pads (2) (tons/year)	Length of Construction and Development Phase (years)	Erosion (3) (tons/year)	Sediment Delivery From Each New Pad (tons/year)	Sediment Delivery From Each Expanded Pad (tons/year)	Total Sediment Delivery from Pads (tons/year)	Delivery Ratio To Stream (4)	Sediment Yield To Stream (tons/year)
Antelope Creek	Loam	0	0	0.044	0.0044	16	0.00	0.0019	0.0002	0.0000	0.1	0.0000
Antelope Creek	Clay Loam	0	0	0.024	0.0024	16	0.00	0.0019	0.0002	0.0000	0.1	0.0000
Antelope Creek	Silty Loam	0	0	0.059	0.0059	16	0.00	0.0029	0.0003	0.0000	0.1	0.0000
Antelope Creek	Sandy Loam	2	2	0.039	0.0039	16	0.01	0.0010	0.0001	0.0001	0.1	0.0000
Subtotal		2	2				0.01			0.0001		0.0000
Lower Pariette Draw	Loam	30	31	0.044	0.0044	16	0.09	0.0019	0.0002	0.0040	0.1	0.0004
Lower Pariette Draw	Clay Loam	1	8	0.024	0.0024	16	0.00	0.0019	0.0002	0.0002	0.1	0.0000
Lower Pariette Draw	Silty Loam	12	20	0.059	0.0059	16	0.05	0.0029	0.0003	0.0026	0.1	0.0003
Lower Pariette Draw	Sandy Loam	66	77	0.039	0.0039	16	0.18	0.0010	0.0001	0.0046	0.1	0.0005
Subtotal		109	136				0.32			0.0114		0.0011
Sheep Wash-Green River	Loam	12	12	0.044	0.0044	16	0.04	0.0019	0.0002	0.0016	0.1	0.0002
Sheep Wash-Green River	Clay Loam	5	5	0.024	0.0024	16	0.01	0.0019	0.0002	0.0006	0.1	0.0001
Sheep Wash-Green River	Silty Loam	5	5	0.059	0.0059	16	0.02	0.0029	0.0003	0.0010	0.1	0.0001
Sheep Wash-Green River	Sandy Loam	22	26	0.039	0.0039	16	0.06	0.0010	0.0001	0.0015	0.1	0.0002
Subtotal		44	48				0.12			0.0048		0.0005
Upper Pariette Draw	Loam	3	3	0.044	0.0044	16	0.01	0.0019	0.0002	0.0004	0.1	0.0000
Upper Pariette Draw	Clay Loam	0	0	0.024	0.0024	16	0.00	0.0019	0.0002	0.0000	0.1	0.0000
Upper Pariette Draw	Silty Loam	1	1	0.059	0.0059	16	0.00	0.0029	0.0003	0.0002	0.1	0.0000
Upper Pariette Draw	Sandy Loam	45	49	0.039	0.0039	16	0.12	0.0010	0.0001	0.0031	0.1	0.0003
Subtotal		49	53				0.13			0.0037		0.0004
Total		**204**	**239**				**0.59**			**0.0200**		**0.0020**

(1) Assumes that typical pad area size is 2.45 acres
(2) Assumes that expanded area is about 10% of the new pad area so erosion is 10% that of new pad.
(3) Assumes that 1/16th of the total number of wells are constructed each year during the construction and development phase and that each well pad is “disturbed” for one (1) year until it is reclaimed and additional erosion over background erosion ceases.
(4) Assumes that 10% of the sediment leaving the pad site is delivered to a stream.
One pad location is located on ‘No Soil’.

Developed by the U.S. Forest Service, the Water Erosion Prediction Project (WEPP) Road model was used to estimate erosion and the sediment load from dirt roads and at road stream crossings. A sample of road stream crossings were randomly chosen for each type of soil, and the longitudinal slope and width of the road at each sample crossing was measured. It was assumed that erosion from the road occurred within 300 feet of each side of the stream and that 100 percent of the eroded material entered the stream (erosion=sediment load). Road traffic also influences the rate of erosion and sediment load. It was assumed that during the construction and development phase of well construction, road traffic would be "low," and that during the production phase, road traffic would be "none." The program was developed for forest service logging roads. Consequently, the use values are relative to what may occur on a typical logging road on forest service land. The erosion and sediment load was calculated at each location using WEPP Roads, and the results were averaged to provide an average erosion and sediment load at a crossing located in each type of soil. These average erosion and sediment load estimates were then multiplied by the number of crossings in each soil type in each watershed to estimate the erosion and sediment contribution from road stream crossings. **Table F-10** contains the erosion and sediment load estimates for existing conditions. **Tables F-11** through **F-14** supply the erosion and sediment load estimates during the construction and development phase for each alternative. **Tables F-15** through **F-18** provide the erosion and sediment load estimates during the production phase for each alternative.

Table F-10. Sediment Yield from Stream Crossing Erosion for Existing Conditions

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	38.2	0.0	1	0.0
Antelope Creek	Loam	0	84.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	33.5	0.0	1	0.0
Antelope Creek	Silt Loam	0	279.2	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	25	38.2	0.5	1	0.5
Lower Pariette Draw	Loam	117	84.3	4.9	1	4.9
Lower Pariette Draw	Sandy Loam	247	33.5	4.1	1	4.1
Lower Pariette Draw	Silt Loam	38	279.2	5.3	1	5.3
Subtotal		427		14.9		14.9
Sheep Wash-Green River	Clay Loam	3	38.2	0.1	1	0.1
Sheep Wash-Green River	Loam	3	84.3	0.1	1	0.1
Sheep Wash-Green River	Sandy Loam	18	33.5	0.3	1	0.3
Sheep Wash-Green River	Silt Loam	10	279.2	1.4	1	1.4
Subtotal		34		1.9		1.9
Upper Pariette Draw	Clay Loam	14	38.2	0.3	1	0.3
Upper Pariette Draw	Loam	81	84.3	3.4	1	3.4
Upper Pariette Draw	Sandy Loam	179	33.5	3.0	1	3.0
Upper Pariette Draw	Silt Loam	11	279.2	1.5	1	1.5
Subtotal		285		8.2		8.2
Total		746		24.9		24.9

Note: It is assumed that the existing wells are in the production phase, so road use is negligible.
Assume that soil density is 90 lbs. per cubic foot.

Table F-11: Sediment Yield at Stream Crossing for Alternative A - Construction and Development Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	128.0	0.0	1	0.0
Antelope Creek	Loam	0	212.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	48.8	0.0	1	0.0
Antelope Creek	Silt Loam	0	477.4	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	29	128.0	1.9	1	1.9
Lower Pariette Draw	Loam	133	212.3	14.1	1	14.1
Lower Pariette Draw	Sandy Loam	344	48.8	8.4	1	8.4
Lower Pariette Draw	Silt Loam	50	477.4	11.9	1	11.9
Subtotal		556		36.3		36.3
Sheep Wash-Green River	Clay Loam	7	128.0	0.4	1	0.4
Sheep Wash-Green River	Loam	10	212.3	1.1	1	1.1
Sheep Wash-Green River	Sandy Loam	30	48.8	0.7	1	0.7
Sheep Wash-Green River	Silt Loam	16	477.4	3.8	1	3.8
Subtotal		63		6.1		6.1
Upper Pariette Draw	Clay Loam	15	128.0	1.0	1	1.0
Upper Pariette Draw	Loam	96	212.3	10.2	1	10.2
Upper Pariette Draw	Sandy Loam	208	48.8	5.1	1	5.1
Upper Pariette Draw	Silt Loam	15	477.4	3.6	1	3.6
Subtotal		334		19.8		19.8
Total		953		62.2		62.2

Assume that soil density is 90 lbs. per cubic foot.

Table F-12: Sediment Yield at Stream Crossing for Alternative B - Construction and Development Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	128.0	0.0	1	0.0
Antelope Creek	Loam	0	212.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	48.8	0.0	1	0.0
Antelope Creek	Silt Loam	0	477.4	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	26	128.0	1.7	1	1.7
Lower Pariette Draw	Loam	127	212.3	13.5	1	13.5
Lower Pariette Draw	Sandy Loam	264	48.8	6.4	1	6.4
Lower Pariette Draw	Silt Loam	38	477.4	9.1	1	9.1
Subtotal		455		30.7		30.7
Sheep Wash-Green River	Clay Loam	3	128.0	0.2	1	0.2
Sheep Wash-Green River	Loam	4	212.3	0.4	1	0.4
Sheep Wash-Green River	Sandy Loam	24	48.8	0.6	1	0.6
Sheep Wash-Green River	Silt Loam	10	477.4	2.4	1	2.4
Subtotal		41		3.6		3.6
Upper Pariette Draw	Clay Loam	15	128.0	1.0	1	1.0
Upper Pariette Draw	Loam	90	212.3	9.6	1	9.6
Upper Pariette Draw	Sandy Loam	182	48.8	4.4	1	4.4
Upper Pariette Draw	Silt Loam	0	477.4	0.0	1	0.0
Subtotal		287		15.0		15.0
Total		783		49.2		49.2

Assume that soil density is 90 lbs. per cubic foot.

Table F-13: Sediment Yield at Stream Crossing for Alternative C - Construction and Development Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	128.0	0.0	1	0.0
Antelope Creek	Loam	0	212.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	48.8	0.0	1	0.0
Antelope Creek	Silt Loam	0	477.4	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	29	128.0	1.9	1	1.9
Lower Pariette Draw	Loam	133	212.3	14.1	1	14.1
Lower Pariette Draw	Sandy Loam	344	48.8	8.4	1	8.4
Lower Pariette Draw	Silt Loam	50	477.4	11.9	1	11.9
Subtotal		556		36.3		36.3
Sheep Wash-Green River	Clay Loam	7	128.0	0.4	1	0.4
Sheep Wash-Green River	Loam	10	212.3	1.1	1	1.1
Sheep Wash-Green River	Sandy Loam	30	48.8	0.7	1	0.7
Sheep Wash-Green River	Silt Loam	16	477.4	3.8	1	3.8
Subtotal		63		6.1		6.1
Upper Pariette Draw	Clay Loam	15	128.0	1.0	1	1.0
Upper Pariette Draw	Loam	96	212.3	10.2	1	10.2
Upper Pariette Draw	Sandy Loam	208	48.8	5.1	1	5.1
Upper Pariette Draw	Silt Loam	15	477.4	3.6	1	3.6
Subtotal		334		19.8		19.8
Total		953		62.2		62.2

Assume that soil density is 90 lbs. per cubic foot.

Table F-14: Sediment Yield at Stream Crossing for Alternative D - Construction and Development Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	128.0	0.0	1	0.0
Antelope Creek	Loam	0	212.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	48.8	0.0	1	0.0
Antelope Creek	Silt Loam	0	477.4	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	27	128.0	1.7	1	1.7
Lower Pariette Draw	Loam	139	212.3	14.8	1	14.8
Lower Pariette Draw	Sandy Loam	299	48.8	7.3	1	7.3
Lower Pariette Draw	Silt Loam	45	477.4	10.7	1	10.7
Subtotal		510		34.5		34.5
Sheep Wash-Green River	Clay Loam	5	128.0	0.3	1	0.3
Sheep Wash-Green River	Loam	10	212.3	1.1	1	1.1
Sheep Wash-Green River	Sandy Loam	34	48.8	0.8	1	0.8
Sheep Wash-Green River	Silt Loam	12	477.4	2.9	1	2.9
Subtotal		61		5.1		5.1
Upper Pariette Draw	Clay Loam	14	128.0	0.9	1	0.9
Upper Pariette Draw	Loam	81	212.3	8.6	1	8.6
Upper Pariette Draw	Sandy Loam	191	48.8	4.7	1	4.7
Upper Pariette Draw	Silt Loam	11	477.4	2.6	1	2.6
Subtotal		297		16.8		16.8
Total		868		56.4		56.4

Assume that soil density is 90 lbs. per cubic foot.

Table F-15: Sediment Yield at Stream Crossing for Alternative A - Production Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	38.2	0.0	1	0.0
Antelope Creek	Loam	0	84.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	33.5	0.0	1	0.0
Antelope Creek	Silt Loam	0	279.2	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	29	38.2	0.6	1	0.6
Lower Pariette Draw	Loam	133	84.3	5.6	1	5.6
Lower Pariette Draw	Sandy Loam	344	33.5	5.8	1	5.8
Lower Pariette Draw	Silt Loam	50	279.2	7.0	1	7.0
Subtotal		556		18.9		18.9
Sheep Wash-Green River	Clay Loam	7	38.2	0.1	1	0.1
Sheep Wash-Green River	Loam	10	84.3	0.4	1	0.4
Sheep Wash-Green River	Sandy Loam	30	33.5	0.5	1	0.5
Sheep Wash-Green River	Silt Loam	16	279.2	2.2	1	2.2
Subtotal		63		3.3		3.3
Upper Pariette Draw	Clay Loam	15	38.2	0.3	1	0.3
Upper Pariette Draw	Loam	96	84.3	4.0	1	4.0
Upper Pariette Draw	Sandy Loam	208	33.5	3.5	1	3.5
Upper Pariette Draw	Silt Loam	15	279.2	2.1	1	2.1
Subtotal		334		9.9		9.9
Total		953		32.1		32.1

Note: It is assumed that road use will be negligible during the production phase.

Table F-16: Sediment Yield at Stream Crossing for Alternative B - Production Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	38.2	0.0	1	0.0
Antelope Creek	Loam	0	84.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	33.5	0.0	1	0.0
Antelope Creek	Silt Loam	0	279.2	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	26	38.2	0.5	1	0.5
Lower Pariette Draw	Loam	127	84.3	5.4	1	5.4
Lower Pariette Draw	Sandy Loam	264	33.5	4.4	1	4.4
Lower Pariette Draw	Silt Loam	38	279.2	5.3	1	5.3
Subtotal		455		15.6		15.6
Sheep Wash-Green River	Clay Loam	3	38.2	0.1	1	0.1
Sheep Wash-Green River	Loam	4	84.3	0.2	1	0.2
Sheep Wash-Green River	Sandy Loam	24	33.5	0.4	1	0.4
Sheep Wash-Green River	Silt Loam	10	279.2	1.4	1	1.4
Subtotal		41		2.0		2.0
Upper Pariette Draw	Clay Loam	15	38.2	0.3	1	0.3
Upper Pariette Draw	Loam	90	84.3	3.8	1	3.8
Upper Pariette Draw	Sandy Loam	182	33.5	3.0	1	3.0
Upper Pariette Draw	Silt Loam	0	279.2	0.0	1	0.0
Subtotal		287		7.1		7.1
Total		783		24.7		24.7

Note: It is assumed that road use will be negligible during the production phase.

Table F-17: Sediment Yield at Stream Crossing for Alternative C - Production Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	38.2	0.0	1	0.0
Antelope Creek	Loam	0	84.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	33.5	0.0	1	0.0
Antelope Creek	Silt Loam	0	279.2	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	29	38.2	0.6	1	0.6
Lower Pariette Draw	Loam	133	84.3	5.6	1	5.6
Lower Pariette Draw	Sandy Loam	344	33.5	5.8	1	5.8
Lower Pariette Draw	Silt Loam	50	279.2	7.0	1	7.0
Subtotal		556		18.9		18.9
Sheep Wash-Green River	Clay Loam	7	38.2	0.1	1	0.1
Sheep Wash-Green River	Loam	10	84.3	0.4	1	0.4
Sheep Wash-Green River	Sandy Loam	30	33.5	0.5	1	0.5
Sheep Wash-Green River	Silt Loam	16	279.2	2.2	1	2.2
Subtotal		63		3.3		3.3
Upper Pariette Draw	Clay Loam	15	38.2	0.3	1	0.3
Upper Pariette Draw	Loam	96	84.3	4.0	1	4.0
Upper Pariette Draw	Sandy Loam	208	33.5	3.5	1	3.5
Upper Pariette Draw	Silt Loam	15	279.2	2.1	1	2.1
Subtotal		334		9.9		9.9
Total		953		32.1		32.1

Note: It is assumed that road use will be negligible during the production phase.

Table F-18: Sediment Yield at Stream Crossing for Alternative D - Production Phase

Watershed	Soil Texture	# of Stream Crossings	Erosion per Crossing (lbs/year)	Erosion (tons/year)	Delivery Ratio	Sediment Yield (tons/year)
Antelope Creek	Clay Loam	0	38.2	0.0	1	0.0
Antelope Creek	Loam	0	84.3	0.0	1	0.0
Antelope Creek	Sandy Loam	0	33.5	0.0	1	0.0
Antelope Creek	Silt Loam	0	279.2	0.0	1	0.0
Subtotal		0		0.0		0.0
Lower Pariette Draw	Clay Loam	27	38.2	0.5	1	0.5
Lower Pariette Draw	Loam	139	84.3	5.9	1	5.9
Lower Pariette Draw	Sandy Loam	299	33.5	5.0	1	5.0
Lower Pariette Draw	Silt Loam	45	279.2	6.3	1	6.3
Subtotal		510		17.7		17.7
Sheep Wash-Green River	Clay Loam	5	38.2	0.1	1	0.1
Sheep Wash-Green River	Loam	10	84.3	0.4	1	0.4
Sheep Wash-Green River	Sandy Loam	34	33.5	0.6	1	0.6
Sheep Wash-Green River	Silt Loam	12	279.2	1.7	1	1.7
Subtotal		61		2.8		2.8
Upper Pariette Draw	Clay Loam	14	38.2	0.3	1	0.3
Upper Pariette Draw	Loam	81	84.3	3.4	1	3.4
Upper Pariette Draw	Sandy Loam	191	33.5	3.2	1	3.2
Upper Pariette Draw	Silt Loam	11	279.2	1.5	1	1.5
Subtotal		297		8.4		8.4
Total		868		28.8		28.8

Note: It is assumed that road use will be negligible during the production phase.

Erosion from roads outside of the stream crossings were also estimated using WEPP:Road. It was assumed that the roads were "outsloped" and runoff would flow off the side of the road and down the embankment, carrying eroded material with it. As previously mentioned, it was assumed that the eroded material would be deposited at the base of the fill slope and would not be transported to a stream so there was no sediment load generated by this erosion source. **Table F-19** contains the erosion estimate for existing conditions. **Tables F-20** through **F-23** present the erosion estimates for each alternative.

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Table F-19. Estimated Road Erosion for Existing Conditions

Soil Texture	Road Width (feet)	Road Slope from Left (%)	Road Length (feet)	Climate Station	Rock %	Road Design	Fill Gradient (%)	Fill Length (feet)	Buffer Gradient (%)	Buffer Length (feet)	Road Surface	Traffic Level	Simulation Period (years)	Unit Erosion (pounds/year/100' of road)		Total Road Length (100 feet)	Total Erosion (tons/year)	
														Construction and Development Phase	Production Phase		Construction and Development Phase	Production Phase
Clay Loam	23.4	0.82%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	9.11	13.42	1,100	5.0	7.4
Loam	22.2	1.48%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	11.38	15.93	7,224	41.1	57.5
Sandy Loam	22.4	4.12%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	4.59	5.97	21,573	49.5	64.4
Silty Loam	27.0	4.60%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	17.61	21.01	2,741	24.1	28.8
TOTAL																	**119.8**	**158.1**

Minimum Road Slope is 0.3%

Table F-20. Estimated Road Erosion for Alternative A

Soil Texture	Road Width (feet)	Road Slope from Left (%)	Road Length (feet)	Climate Station	Rock %	Road Design	Fill Gradient (%)	Fill Length (feet)	Buffer Gradient (%)	Buffer Length (feet)	Road Surface	Traffic Level	Simulation Period (years)	Unit Erosion (pounds/year/100' of road)		Total Road Length (100 feet)	Total Erosion (tons/year)	
														Construction and Development Phase	Production Phase		Construction and Development Phase	Production Phase
Clay Loam	23.4	0.82%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	9.11	13.42	1,513	6.9	10.2
Loam	22.2	1.48%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	11.38	15.93	9,823	55.9	78.2
Sandy Loam	22.4	4.12%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	4.59	5.97	29,822	68.4	89.0
Silty Loam	27.0	4.60%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	17.61	21.01	4,220	37.2	44.3
TOTAL																	**168.4**	**221.7**

Minimum Road Slope is 0.3%

Table F-21. Estimated Road Erosion for Alternative B

Soil Texture	Road Width (feet)	Road Slope from Left (%)	Road Length (feet)	Climate Station	Rock %	Road Design	Fill Gradient (%)	Fill Length (feet)	Buffer Gradient (%)	Buffer Length (feet)	Road Surface	Traffic Level	Simulation Period (years)	Unit Erosion (pounds/year/100' of road)		Total Road Length (100 feet)	Total Erosion (tons/year)	
														Construction and Development Phase	Production Phase		Construction and Development Phase	Production Phase
Clay Loam	23.4	0.82%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	9.11	13.42	1,128	5.1	7.6
Loam	22.2	1.48%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	11.38	15.93	7,622	43.4	60.7
Sandy Loam	22.4	4.12%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	4.59	5.97	22,389	51.4	66.8
Silty Loam	27.0	4.60%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	17.61	21.01	2,741	24.1	28.8
TOTAL																	**124.0**	**163.9**

Minimum Road Slope is 0.3%

Table F-22. Estimated Road Erosion for Alternative C

Soil Texture	Road Width (feet)	Road Slope from Left (%)	Road Length (feet)	Climate Station	Rock %	Road Design	Fill Gradient (%)	Fill Length (feet)	Buffer Gradient (%)	Buffer Length (feet)	Road Surface	Traffic Level	Simulation Period (years)	Unit Erosion (pounds/year/100' of road)		Total Road Length (100 feet)	Total Erosion (tons/year)	
														Construction and Development Phase	Production Phase		Construction and Development Phase	Production Phase
Clay Loam	23.4	0.82%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	9.11	13.42	1,513	6.9	10.2
Loam	22.2	1.48%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	11.38	15.93	9,823	55.9	78.2
Sandy Loam	22.4	4.12%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	4.59	5.97	29,822	68.4	89.0
Silty Loam	27.0	4.60%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	17.61	21.01	4,220	37.2	44.3
TOTAL																	**168.4**	**221.7**

Minimum Road Slope is 0.3%

Table F-23. Estimated Road Erosion for Alternative D

Soil Texture	Road Width (feet)	Road Slope from Left (%)	Road Length (feet)	Climate Station	Rock %	Road Design	Fill Gradient (%)	Fill Length (feet)	Buffer Gradient (%)	Buffer Length (feet)	Road Surface	Traffic Level	Simulation Period (years)	Unit Erosion (pounds/year/100' of road)		Total Road Length (100 feet)	Total Erosion (tons/year)	
														Construction and Development Phase	Production Phase		Construction and Development Phase	Production Phase
Clay Loam	23.4	0.82%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	9.11	13.42	1,211	5.5	8.1
Loam	22.2	1.48%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	11.38	15.93	7,983	45.4	63.6
Sandy Loam	22.4	4.12%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	4.59	5.97	24,056	55.2	71.8
Silty Loam	27.0	4.60%	300	Altamont, UT	10	Outsloped, unrutted	50	10	1	1000	Native	Low	50	17.61	21.01	3,103	27.3	32.6
TOTAL																	**133.5**	**176.1**

Minimum Road Slope is 0.3%